METALLURGIA

THE BRITISH JOURNAL OF METALS.

MARCH, 1934. VOL. IX., No. 53.

Annealing Steel Sheets in Electric Furnaces

Electric energy, as a source of heat, is used extensively in industrial heating operations, often at higher energy cost, because of the indirect advantages of electric heating equipment, which may influence the manufacturing process as a whole. In this article an electric heating equipment installation is described which has been designed for annealing electrical steel sheets.

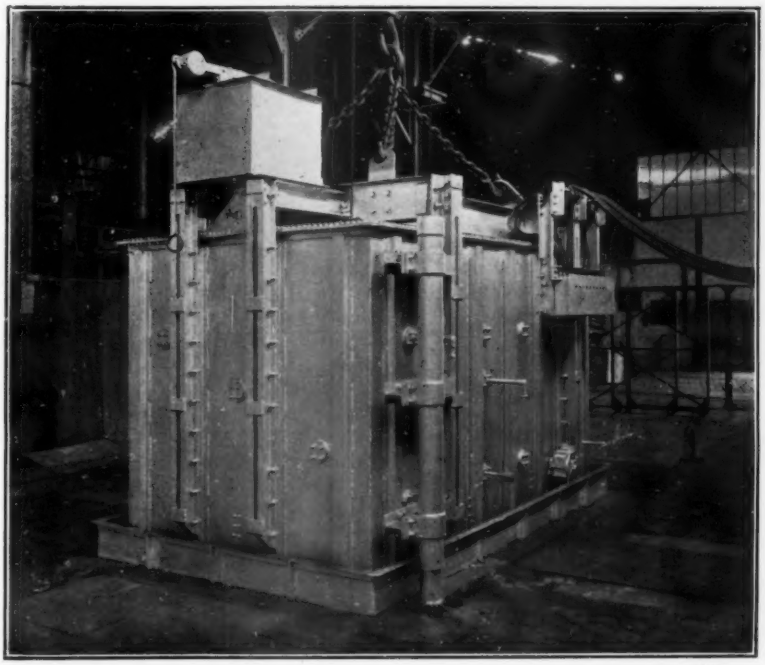


Fig. 1.—Bell type sheet annealing furnace, with a capacity of 10–12 tons of steel sheets.

THE application of electric heating to the heat-treatment of metallurgical products entails many advantages which become more evident when these products are of high intrinsic value, as an improvement in quality or a reduction in wastage will often pay for the power bill many times over. When, however, low-priced products are to be treated, such as plain carbon steel, or low-grade alloy steel sheets, it becomes necessary to examine more critically the justification or otherwise for electric heating. Recent developments show that the application of electric heating for this process is gaining favour, and probably the greatest influencing factor in its use is the ready application of controlled atmospheres with its many attendant benefits. In addition to the maintenance of an atmosphere of gas, such as hydrogen or carbon monoxide, without muffles, the relatively higher heat balance of the electric furnace has tended towards the establishment of new standards of production.

The development in the application of electric heating for this purpose has led to the installation of several large bell-type furnaces in this country and abroad. These furnaces are in use for the annealing of electrical steel sheets, and were constructed by the Electric Resistance Furnace Co., Ltd. They are designed to take an average charge of 10–12 tons of stacked sheets. Before describing this plant, however, it will be advantageous to consider briefly some of the metallurgical problems involved.

The annealed sheets are used for the assembly of cores for rotating machinery—dynamos and alternators,—and also for transformers. For this purpose permeability and consequently magnetising current are of importance, but these are not materially affected by different methods of annealing, if the time cycle for heating and cooling is maintained within certain limits. The total magnetic losses, which are made up of hysteresis and eddy current losses, can, however, be appreciably affected by annealing.

The type of material used for these sheets contains between 1 and 4·2% silicon, while the carbon, sulphur, and manganese are kept to very low limits, preferably below 0·02%, but this is only attained in the best quality material. The silicon serves a dual purpose. It markedly increases the electrical resistance, thereby reducing eddy current loss. Approximately 1% silicon gives an increase in resistance of 10 in. microhms/cm^3. The silicon also raises the α to γ change-point and makes for crystal growth. Broadly speaking, crystal boundaries exert a restraining influence on the passage of magnetic flux, and the larger the grains within certain limits, the lower the hysteresis loss. The grains, however, must not be large enough to induce excessive brittleness. What is equally important

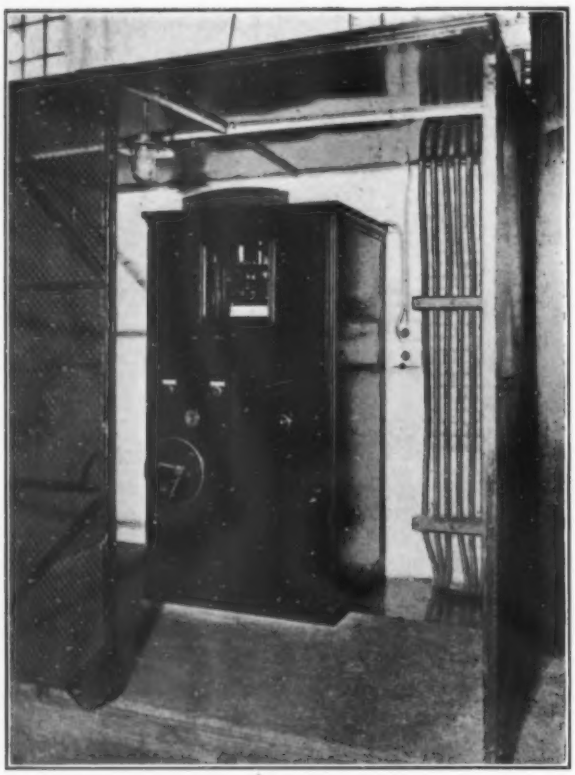


Fig. 2.—Cubicle containing automatic temperature recording controller.

is uniformity of grain size, and it is in this direction that electric annealing has done much to produce an improvement in quality.

Carbon has a particularly deleterious effect on the magnetic losses if it is in solution or in the cementitic state. By using the correct annealing temperature, much of the carbon can be made to separate as graphite. The remarkable effect of carbon may be realised when it is stated that for each increment in carbon content of 0·04% (above an initial content of 0·04%) the losses increase by approximately 1 watt/kg. at 10,000 gauss, 50 cycles. By the application of hydrogen annealing, a definite improvement in magnetic losses has been effected, and it is more than probable that this is due to decarburisation and a reduction of the oxide content of the steel by hydrogen.

The following are some representative results taken during a year's operation.

ANNEALED IN BOXES IN COAL-FIRED FURNACE.

Sample No.	Magnetic Induction B.		Frequency.	Analysis.		Thickness of Sheet.	—
	10,000 Gauss.	14,000 Gauss.		Si.	C.		
B 1	2·07	3·89	50	3·19	0·055	0·35 mm.	Unpickled
B 2	1·86	3·48	50	3·24	0·045	0·35 mm.	,,
B 3	2·00	3·84	50	2·7	0·065	0·35 mm.	,,
B 4	1·97	3·50	50	2·7	0·065	0·35 mm.	,,
C 1	1·63	3·36	50	3·9	0·06	0·35 mm.	,,
C 2	1·60	3·30	50	4·0	—	0·35 mm.	,,
D 1	1·35	2·81	50	4·1	0·045	—	,,
D 2	1·29	2·68	50	4·08	0·040	—	,,
SAME SAMPLES ELECTRICALLY ANNEALED IN HYDROGEN.							
B 1	1·78	3·37	50	3·19	0·045	0·35 mm.	Unpickled
B 2	1·55	3·02	50	3·24	0·040	0·35 mm.	,,
B 3	1·73	3·34	50	3·7	0·050	0·35 mm.	,,
B 4	1·64	3·17	50	2·7	0·050	0·35 mm.	,,
C 1	1·29	2·77	50	3·9	0·050	0·35 mm.	,,
C 2	1·23	2·65	50	4·0	0·050	0·35 mm.	,,
D 1	1·10	2·41	50	4·1	0·040	0·35 mm.	,,
D 2	1·08	2·36	50	4·08	0·030	0·35 mm.	,,

The tabulated results speak for themselves, but it should be emphasised that these results can be obtained consistently by repeating the time and temperature cycle. The previous need for double annealing in many cases is therefore eliminated.

The furnace itself is illustrated in Fig. 1, and it consists of a rigid outer casing which is made perfectly gas-tight; there being no need for internal muffles and boxes. The sheets are stacked in a specially constructed base through which the protective gas enters. Two bases are provided, one being charged while the other is in service. The elimination of boxes is an important factor, and one which clearly brings out one of the attendant advantages of this system of annealing. Previously the sheets were stacked on a carriage or bogie which was rolled into a coal-fired furnace on balls. This carriage had a sand seal into which a heavy cast box or cover was dropped.

The weight of carriage and box average 4 tons for 5-ton charge. This had the effect of considerably prolonging the time cycle, which averaged 50–60 hours, as the heat had to penetrate a 1½ in. thickness of box before heating the charge. Moreover, it was impossible to eliminate oxidation with any completeness, even by using a coal-gas atmosphere during cooling. The heating time in the electric furnace was reduced by more than half, while the automatic features of gas and temperature control have almost eliminated labour costs except for charging and discharging.

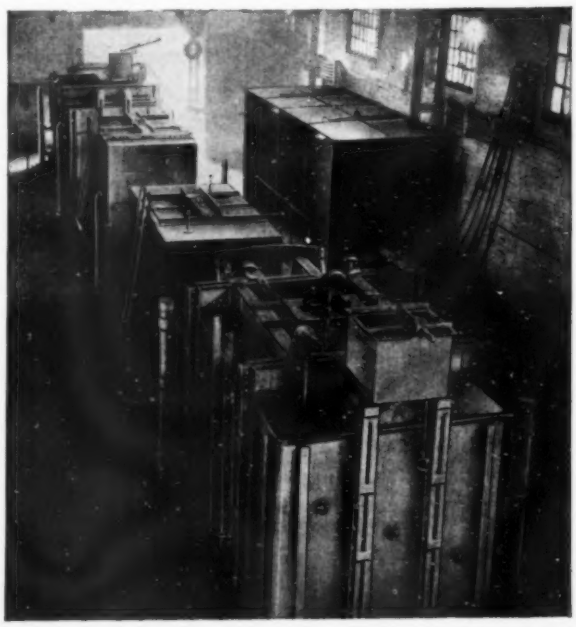
The internal dimensions of the furnace are 9 ft. 6 in. × 4 ft. 6 in. × 4 ft., and the heating elements, which are disposed on the four walls of the furnace, are arranged to dissipate 300–350 k.w. during heating. When the charge is up to temperature, the rating is automatically reduced, and only sufficient energy is required to balance heat losses and to provide for the penetration of heat to the centre of the stack.

An automatic temperature recording controller is arranged in the cubicle Fig. 2, and from a cursory examination of the curve it is possible to ascertain when the centre of the stack of sheets has reached the desired temperature.

In order to utilise the heat in the furnace, the sheets are cooled in a reducing atmosphere under a gas-tight hood. Fig. 3 shows a view of the whole annealing bay with two furnaces and the two cooling hoods. The sheets are removed from the hoods and a new charge restacked before the time cycle in the furnace is complete. The second furnace shown in Fig. 3 is a repeat installation, and was built 18 months after the first furnace had given entire satisfaction and had proved its value.

The scope of this system of annealing is not restricted to electric sheets, and has been used successfully for the annealing of motor-car body sheets subsequent to normalising followed by pickling and cold rolling.

Fig. 3.—The complete furnace instalment in the annealing bay.



It is possible in this system of annealing to produce economically a mirror-bright surface free from the characteristic blue fringe. It may also be used for the high temperature or "black" annealing of tinplates and similar sheets. These sheets are oxidised during hot rolling, especially the outer sheets of a pack . These can be introduced into a controlled atmosphere furnace and a silver finish produced. Such sheets can be processed—*i.e.*, cold rolled and white annealed without any intermediate pickling. Metal losses are eliminated, as are pickling and handling costs, and it is probable that these, as well as advantages resulting from reduced labour charges, would render this treatment economical.

The Kuznetsk Iron and Steel Works

With new plant included in the 1934 programme, the iron and steel works at Kuznetsk will have a capacity of approximately four million tons a year; this, it will be appreciated, is nearly as much as the pre-war capacity of all Russian plants. Brief information regarding these works is given in this article.

THE Kuznetzk iron and steel works is a giant enterprise, and comprises the most modern plant and equipment. The building of the works and the installation of suitable plant was the occasion of considerable dispute, as, originally, the intention was to develop the works on a smaller capacity. For instance, the initial plans were prepared for an appropriate annual capacity of 327,000 tons of pig iron, 400,000 tons of steel, and 435,000 tons of rolled sections; while the capacity of the power station was originally planned for 37,000 kw. Since then, however, the original plans have been much enlarged, and the works and plant under construction have a projected capacity of approximately 1,200,000 tons of cast iron, 1,450,000 tons of steel, and 1,130,000 tons of rolled sections, while the power capacity will be 108,000 kw. The final decision to increase the capacity of these works was made in 1930, when considerable building operations were already in progress, but remarkable progress has since been made under great difficulties.

The peculiar difficulties of Kuznetskstroi for such a large plant lay in the fact that it was not only necessary to carry out building operations, but to develop a new region, to create supplies of local building materials, electric energy, water, etc., the difficulties being aggravated by the remoteness of the building site from industrial centres. The decision of the Soviet Government, in June, 1930, to create a second iron and steel centre for the U.S.S.R. in the East, and to speed-up the building of the works at Kuznetsk and Magnitogorsk aroused the interest of the whole country. Large numbers of workers, craftsmen, and engineers were sent to the site, the requisite funds were made available, and in the summer of 1930 the building of the Kuznetsk Works was proceeding rapidly.

During the last few years a tremendous amount of work has been done on the site, particularly in the building operations, while some 67,000 tons of steel structures have been erected, 287 kilometres of railways have been made, and plant has been installed to the value of 118 million roubles. From outside alone 190,000 wagon-loads of equipment and building materials have been delivered, and, so far, the amount expended in the building and equipment of these works and auxiliary enterprises is not less than 600 million roubles.

It is now the second year since the first section of the works was put into operation. By the end of the present year it is expected that practically the whole works will be finished, and the second section will be gradually brought into operation. This will entail much work and the expenditure of another 160 million roubles.

In 1932, when the first blast-furnace units were put into operation, they had to be run at the same time as the building operations were in progress, which naturally resulted in considerable strain. The technical difficulties presented this year will cause an even greater strain upon the organising ability, for 75% of the plant will be working in the early months while building operations are going on.

The plan for 1934 provides not only for the starting of the principal shops and units, but all the auxiliary buildings to ensure a normal working of the plant. Thus, during the first quarter of the year the central laboratory is to be opened, the casting shop will be operated to its full capacity, while other departments will be operating at an increased capacity. The water supply, drainage system, telephone system, electric power supply, as well as a ferro-concrete tunnel underneath the works, are already finished, and this year it will become possible properly to lay out the site, to make roads and to plant trees.

During the last few years a sum of over 30 million roubles has been expended in the sinking of mines, the building of enriching works; a sum of approximately 5 million roubles on winning minerals from the earth, like dolomite, lime, quartz; a sum of 11 million roubles has also been expended on prospecting for ores. The deposits of Siberian manganese are already being exploited, and the raising of fire-clay has been extended.

A number of other subsidiary works has been built, such as a factory for wood products, a brick factory, shops for the manufacture of iron structures. On what was but a short time ago a desert place, a town of 200,000 inhabitants has been created, with a water supply, drainage system, telephones, electric light, and tramways. The town provides facilities for higher education, in addition to technical schools, factory schools, model schools, a theatre, a kinema, public baths and laundries. A sum of 70 million roubles has been expended on housing and municipal amenities, which are to be greatly extended during 1934.

From 1932, with the gradual starting of the different shops and units, a number of complicated questions had to be solved in operating this vast and complex enterprise. At the same time, the administration had to cope with individual units which were not prepared for the winter. There were interruptions in the work during the winter of 1932-33, frequently entailing the stoppage of entire units. Now there is not a single important section of the works which has not been completely prepared for the winter.

From the moment the works were started new raw materials had to be used—Magnitogorsk and Tebelsk ore and coke from the Donetz Basin. The fuel for coking in the Kuznetsk ovens was finally decided and supplied by the Commissariat for Heavy Industries in December, 1933, two years after the coke-ovens had been working, during which time different brands of coal had been tried and carefully investigated. The greatest difficulty which had to be overcome was the co-ordination of all the parts of so large and complex an undertaking as the Kuznetsk Combine, but apparently this has been achieved since that part of the plant working is progressing smoothly. The inter-transport system of the works handles 180,000 wagon-loads a year, out of which last year 100,000 wagon-loads went to serve the shops in operation.

The control, not only of the different units and machines, but of the whole of the system of supply and intercommunication is due to the extensive work carried out by the administration during 1933. The machine shops and foundries are still unable to supply the necessary spare parts and repair service, inasmuch as they still have to carry out work for building purposes, but this is gradually being remedied, and as building proceeds their ability to meet these demands will increase.

The staff of workers is composed of 90% former Siberian collective farmers and builders, and navvies from Kuznetskstroi. The creation of this staff, the training of the men to do new kinds of work, and to handle complex equipment, was a very difficult task. Two years of hard work were required to create a suitable staff of workers. During the year 1933 as many as 37,000 workers were passed through special technical courses. The present staff of 15,000 workers employed in the shops and units of the Kuznetsk works is one of the great achievements of West Siberia.

During the year 1933 the works provided the country with 566,000 tons of coke, 387,000 tons of pig iron, 243,000 tons of steel, 220,000 tons of products from the blooming mills, and 86,000 tons of rails. In 1934 it is planned that these works will provide the country with 200,000 tons of coke, 1,000,000 tons of pig iron, 775,000 tons of steel, and 550,000 tons of products from the blooming mill. That is to say, the Kuznetsk iron and steel works are required to produce 10% of the entire Soviet output of pig iron, 75% of the entire output of axles, and 50% of the entire output of rails.

The building of this gigantic plant has laid the foundations for an expansion of industrial construction in Siberia, particularly as during the building a powerful iron ore supply has been located on deposits running into hundreds of millions of tons of ore.

Plans have been made and operations have commenced on the building of a second iron and steel works at Kuznetsk. The object is to exploit to the full the rich deposits of Kuznetsk coal and ore. In the building of the second works it is not proposed to use the railway lines for the purposes of transporting material; to avoid congestion, such material as is required from without will be transported on the branch lines. No outside materials will be used for exploiting the second works, which will be run entirely on local coal, ores, etc. The iron necessary for the construction of the second works, as well as the rails for its transport system, will be supplied by the first Kuznetsk works. A new cement works will supply all the necessary cement, and timber and other building materials can also be obtained locally.

The second Kuznetsk works is to be built not only because the Stalin region is rich in ores, but because Siberia as a whole, from the Urals to the Far East and Central Asia, requires ever-increasing quantities of metal for her metal manufactures, and is essential to the general industrial development. The second Kuznetsk works is to be built in two sections, each to have an output capacity of 1,000,000 tons of metal.

According to the estimates of the planning authorities, the region covered by this development will require at the end of the second five-year plan 1,500,000 tons of metal—mainly sheet and pipes. The new works are intended to meet this demand. A provisional estimate by the planning organisations in Siberia put the requirements of the region in metals at the end of the third five-year plan at 3·5 million tons.

The second five-year plan provides for much railway construction, particularly in the East of the Union. Consequently, rails will be required, steam locomotives, wagons, etc. It is therefroe intended to build near the second Kuznetsk works a number of works producing transport machinery, the first among them being a steam locomotive works (the building of which has actually been decided on), a wagon works with an output capacity of 36,000 wagons, as well as smaller auxiliary works.

Aluminium Paint.

As a decorative medium, protective coating, light reflector, heat reflector or conserver, waterproofing medium, or as a primer, aluminium paint is being used to an increasing extent. This metallic paint is made from aluminium powder, consisting essentially of minute flat particles which are prevented from welding together by the addition of a small quantity of grease.

Aluminium paint differs fundamentally from ordinary paint in that the particles of the pigment are not granular, but are extremely thin flakes, which, owing to their thinness and lightness, have the unique property of rising to the surface of the medium and "joining hands" under the influence of surface tension, thus forming a series of thin metallic layers, having the properties of a sheet of metallic foil. It is obvious that it will require far less material of this form and characteristics to create an opaque layer which will blot out the surface below, which means that a much thinner coat is required to keep out light and moisture than in the case of a non-metallic paint. As this layer of metallic flakes is opaque to light, it prevents the destructive violet and ultra-violet rays from penetrating to the binding medium beneath, this being the main cause of bad weathering of ordinary paint.

The fine lustre of this paint makes it particularly suitable for obtaining striking decorative effects; it is also valuable for its protective qualities, especially against sun, rain, and impure atmospheric conditions. Since it is not attacked by sulphur or chlorine, it is useful in industrial districts and by the sea coast, and it can be used on wood, steel, non-ferrous metals and cement with equally satisfactory results. It is noteworthy that aluminium is electropositive to all the common metals, and prevents excessive corrosion at points where the paint has been chipped off.

Possessing a highly polished surface when applied, aluminium paint has a high light and heat reflector value, and any metallic surface which reflects the light and heat waves also acts as a bad heat radiator or transmitter—that is to say, the highly polished surface acts as a bar to the passage of heat waves in either direction. Tests have shown that a perfectly dull black surface transmits or radiates heat waves from a hot body into the surrounding atmosphere at the greatest rate, and highly polished metallic surfaces at the lowest rate. This property is made use of for reducing the radiation of heat from hot objects such as boilers, furnaces, steam-pipes, annealing ovens, and similar plant. In such cases the aluminium paint not merely reduces the heat losses and thereby saves money, but it also maintains the surrounding atmosphere at a more even temperature, with resultant pleasanter and healthier working conditions for the men employed, and consequent higher outputs.

The ordinary medium used in making up aluminium paint will not withstand materially higher temperature than ordinary paint, but there are now special vehicles available which will withstand temperatures as high as 800° C. Where the surface is even hotter than this, the medium is merely burned away, leaving the aluminium intact, and at a dull red heat it slowly alloys with the surface of the metal and disappears, and must be renewed at intervals if it is desired to maintain the heat-reflecting properties.

Aluminium paint is mechanically stronger than ordinary paint, owing to its metallic content and the shape of the individual particles. Being chemically inactive to the atmosphere, deterioration of the surface can only take place through rain and grit causing a slow abrasion, each of the successive layers of flakes and medium being thus worn slowly away in turn. As no light can penetrate to the lower layers of medium these maintain their properties until exposed in turn to be worn down, whereas in the case of ordinary paint a point is soon reached where the whole paint starts to crumble away in a fine powder, this being particularly the case with white paints.

METALLURGIA

The British Journal of Metals

★ The source of all matter extracted from this Journal must be duly acknowledged; it is copyright. ★

Contributions suitable for the editorial pages are invited. Photographs and drawings suitable for reproduction are welcome. Contributions are paid for at the usual rates.

PRINCIPAL CONTENTS IN THIS ISSUE:

	Page
Annealing Steel Sheets in Electric Furnaces. *In this article an electric heating equipment installation is described which has been designed for annealing electrical steel sheets.*	133–135
The Kuznetsk Iron and Steel Works *Considerable development of these works is included in the 1934 programme, the object being to exploit the rich deposits of Kuznetsk coal and iron. This article gives brief information regarding these works.*	135–136
Aluminium Paint	136
Bilateral Agreements Improve International Trade	138
Trade Barriers and British Shipping	139
Blast-furnace Gas Cleaning *The first two-stage electrostatic plant. The latest scientific method of cleaning blast-furnace gas operates on the electrostatic two-stage principle; a brief description of the first plant to operate on this principle is given in this article.*	140
The Development of Materials for Poppet Valves. By C. C. Hodgson *The first part of this article reviewed briefly the subject of valve requirements, with special reference to the exhaust valve. In this article the author traces the development of the materials from which they have been made.*	141–143
Corrosion by Sea and Ozone	143
Reviews of Current Literature	144
Repairs to Steel Furnaces. By Walter Lister *A method of burning-in the bottom of an open hearth is described and important factors necessary to a successful repair are stressed. Different materials are discussed for both acid and basic furnaces.*	145–147
Crushing of Limestone *A gyratory crusher is briefly described which will crush extremely hard materials and will give continuously a crushed product of any desired size in the cubical condition.*	147–148
A.S.T.M. Proceedings, 1933	148
Institute of Metals *Annual General Meeting held in London. Papers presented at the several technical sessions of this meeting are briefly summarised.*	149–152
Automatic Reversal of Open-hearth Furnaces *A reversal system which operates automatically on a temperature-difference principle is discussed.*	153–154
Straits Tin	154
A Projected British Foundry School. By J. G. Pearce, M.Sc., F.Inst.P., M.I.E.E. *A new scheme is described which is fundamentally different from any other scheme of training. The author discusses other training schemes in operation which have led to the present development.*	155–156
Sodium Carbonate in Iron and Steel Works	158
Recent Developments in Tools and Equipment *Rolling-mill Plant. Large Plate-bending Machine. Press Machines. Wire Machinery.*	159–161
Protection of Steel Pipe Lines	161
Glass Silk for Heat Insulation *Claimed to combine low conductivity, light weight, resistance to vibration, resistance to high temperatures, and to retain these properties during constant use.*	162
Business Notes and News	163–164
Some Recent Inventions *Cold-working Non-magnetic Steel Rings. Annealing Steels and Alloys.*	164
Metal Prices	166

Subscription Rates throughout the World - - 24/- per annum, Post free.

Published Monthly by the Proprietors, THE KENNEDY PRESS LIMITED, at 21, Albion Street, Gaythorn, Manchester.

Telegrams: "Kenpred," Manchester. *Telephone: Central 0098.*

METALLURGIA

THE BRITISH JOURNAL OF METALS.

Bilateral Agreements Improve International Trade.

THE disciplinary action of years of bitter and cruel experience is apparently convincing man that the world must move backwards and forwards, in the essentials, as one unit. The war hastened evolutionary processes, and the post-war years have seen the industrialising of countries that were previously predominantly agrarian, and it will not be during the present generation that the balance will be completely restored. Despite the reactionary tendencies of Germany, of Italy, and in some respects of Russia, a refreshing wind of international toleration and understanding is blowing through the Chancelleries of Europe, which is reflected in an increasing export trade. The political experimentalists may be realising that a nation cannot live unto itself alone. Currency depreciations, financial restrictions, and tariffs interfere with international trade and keep the world poor; but, on the other hand, trade agreements and conferences between the industrialists of different countries indicate the growth of a broader view of international relations.

The spirit of nationalism, which has been so intense in the people of some countries, has tended towards isolation, a condition which narrows activities, reduces trading scope, and undoubtedly retards economic development on profitable lines. This fact is gradually being appreciated, and even in America peculiar changes are working. Judging by her representatives' attitude at the World Economic Conference, for instance, few people would be prepared to hear, a few months after the sittings of that body were suspended, the same policy that the British Government advocated there being voiced from the White House. But, after a year's experience of the "new deal," Mr. Roosevelt is obliged to admit that economic nationalism cannot be supported, and that the collapse of international trade means "idle hands, still machines, ships tied to the docks, and despairing farms and households." The plan to codify industry in America was consistent only with reduced foreign competition in the home market and the withdrawal of America as a competitor in foreign markets.

It will be appreciated that America is in a better position to be self-supporting than any other country, for approximately nine-tenths of her production is absorbed in the home market. It is different with agriculture, however, which is dependent to a large degree on foreign markets. For this reason, Mr. Wallace has been warning his countrymen that the United States must either admit imports or forty million acres of land must go out of cultivation, and millions of people must leave the farms and find other work. From an international point of view, Mr. Roosevelt's tariff message is a hopeful sign, but it must be realised that a change in that country's commercial policy will not be brought about without a severe struggle.

There are many indications pointing to a wider acknowledgment of the influence each nation can exert in opening international trade channels and in restoring normal commercial transactions between nations. With Great Britain the fact that she can never be self-supporting has probably been of considerable assistance in her efforts towards recovery. As the world's largest importer, she has been able to use her purchasing power to promote reciprocal trade. A prosperous export trade is a vital necessity, otherwise it would be impossible to import her requirements from overseas and strike an economic balance. For this reason the British Government has concentrated on trade agreements with individual nations in an effort to balance between the import and export trade carried on with these nations. In effect, these agreements constitute a means for promoting freer trade between Great Britain and the countries concerned. It was recognised that, though trading restrictions could not be entirely removed, they could be simplified and reduced to facilitate, rather than hinder, trade between various countries, and an arrangement arrived at which would be of mutual benefit to the parties concerned.

The more recent trade agreement entered into by Great Britain—that with Russia—represents a real and substantial achievement. A certain disappointment will probably be felt in Britain that it does not go further or that a position of balanced trade is not obtained more quickly, but the negotiators were faced with peculiar circumstances, and it was impossible to determine what the mechanism of Russian trading could accomplish. However, a controlled arrangement with its increasingly favourable ratio is much more satisfactory than the uncontrolled and difficult conditions which have been faced by British manufacturers during the past few years. The main point is that it is an amicable arrangement to promote trade between these two countries. Another trade agreement which Britain has under consideration is that with France, whose representatives are at present in London, and it is confidently expected that an arrangement will be determined which will overcome the difficulties at present existing and create a basis for increased exchange of commodities between these nations.

The evidence of improving demand in the United Kingdom, which is steadily fortified by her employment figures and confirmed by increased railway receipts, retail trade percentage, and the like, is of considerable importance to other countries. It is being watched keenly because it indicates the increasing importance of Britain as a market to them, and must suggest to those with whom she is entering upon trade negotiations that Britain can offer a valuable market in return for adequate concessions. Even Mr. Roosevelt has expressed his intention to try by a series of bilateral negotiations to increase American foreign trade on both sides of the balance-sheet—that is, by imports as well as by exports. Certainly, it is being increasingly recognised that no country can hope to export without taking something in return, and it may be that an intermediate method is being fashioned which constitutes a bargaining arrangement between nations for a wider interchange of merchandise and service on a mutually agreed basis. And in view of the success achieved by the United Kingdom in entering into these agreements, as a result of which her trade has increased, this method may be instrumental in subduing excessive economic nationalism, excessive tariffs, quotas, and other trade impediments which have had so much to do in preventing recovery from the world depression.

It is noteworthy that though Great Britain was unsuccessful in removing restrictions on international trade as a Free Trade country, she is achieving this object since her acceptance of protective tariffs, by means of these bilateral agreements, and is showing that the change is being effected with profit to all the nations concerned. Certainly, as far as Great Britain is concerned, the indices of trade indicate expanding orders and revenue, which seem to show that her trade is definitely on the upgrade.

TRADE BARRIERS AND BRITISH SHIPPING.

THE past year has been one of increasing gravity for British shipping. The slight improvement in international trade in recent months and the distinct signs of recovery in the home industry have so far barely touched shipping. It is generally recognised that shipping, as a trade barometer, is sensitive to downward movements, but it responds very slowly to recovery. Tramp freights are on the average 22½% below pre-war conditions, which means that a loss is being experienced on almost every voyage; in addition, however, the scarcity of cargoes increases the number of voyages which must be made in ballast.

The loss of coal exports is probably the greatest blow to shipping, for in comparison with pre-war conditions it has meant some 700 fewer vessels with outward cargoes each month, while the further increase of world tonnage, operated on oil fuel, to 45·4% of the total has aggravated the problem through the consequent loss of bunker exports. The tramp section has declared itself to be on the verge of bankruptcy, and if British tramp shipping is to survive, as Major Robert J. Dunlop said in his presidential address at the recent annual meeting of the Chamber of Shipping, some definite action must be taken forthwith. The ultimate objective must be the restoration of international trade. The tide of world trade is commencing to flow very, very slowly, but the nations are still feverishly working to build higher and higher against it.

It is not fully appreciated that shipping services represent Great Britain's principal export, greater in value even than cotton or iron and steel, and nearly three times as great as machinery or woollen and worsted manufactures. These invisible shipping exports amounted to about £59,000,000 in 1933, in comparison with £62,000,000 in 1932, £130,000,000 in 1929, and £94,000,000 in 1913. While the total British tonnage is a little less than in 1914, its effective carrying capacity has been slightly increased through greater efficiency, but by comparison other countries have increased enormously: France, for instance, by 51%, Italy by 89%, Japan by 149%, and the United States of America, though she has reduced her tonnage since 1923 by 22%, increased it before that time by 218%. And these countries have made this increase possible by means of subsidies which have swamped the freight market and converted a healthy world industry from an asset into a burden.

As the world's biggest buyer, Great Britain can surely demand that adverse trade balances be redressed by fuller purchase of British shipping services, in return for other countries' goods. For once this need has been recognised in the Anglo-Soviet temporary trade agreement. One of the important points this agreement contains is that Russia must make fuller use of British shipping—surely the first time that a trade agreement has recognised shipping services as a visible rather than an invisible export. In the provisions to maintain the balance of Anglo-Soviet trade on the ratios agreed upon, Russia has every incentive to make as much use as possible of British ships to carry her trade as well as to purchase her requirements of second-hand tonnage from British owners, because the value of the service and the tonnage will be treated as a payment from the Soviet.

The statement of policy on behalf of the British shipping industry recently placed before the President of the Board of Trade should be acted upon in order to restore world trade, on which all shipping depends, and to discourage practices inimical to trade. It is proposed, for instance, that Great Britain, in consultation with the Dominions, should join with other nations in an effort to restore world trade. This group should include all the great creditor nations and should agree to the principles to be observed, and concede most-favoured-nation terms only to each other. Among these principles should be an obligation on each creditor nation to accept such payment in goods and services as will offset its creditor position, and on all co-operating nations an obligation to stabilise prices and currencies and restore the freedom of the seas for peaceful commerce. Great Britain must lose no opportunity to promote the restoration of world trade; at the same time she must restore her agriculture, her industries, her shipping, and keep a just balance between them. Tariffs and quotas, however, may easily reach a point at which they seriously injure shipping, her principal export, and so endanger her safety. Fortunately, much progress has been made in the negotiation of bilateral agreements which have improved trading conditions, and these may lead naturally to the formation of a group of countries prepared to trade with one another on terms of equity and justice, in which both manufactures and services will be accepted for foreign goods.

Forthcoming Meetings

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.

April 6. "The White Patent Combined Marine Steam Engine," by W. A. White.

TEES-SIDE BRANCH.

April 19. "A Review of Oil Engine Air Charging and Fuel Injection Systems," by W. S. Burn, M.Sc.

THE ROYAL AERONAUTICAL SOCIETY.

April 5. "Engines," by Capt. A. G. Forsyth.

April 12. "Speed and the Future of Commercial Aircraft," by Mons. Louis Breguet.

INSTITUTE OF METALS.

BIRMINGHAM SECTION.

Mar. 20. "Rolling Mill Practice," by A. V. Russell, Wh.Ex.

LONDON SECTION.

April 12. Annual General Meeting and open discussion.

INSTITUTE OF BRITISH FOUNDRYMEN.

BIRMINGHAM BRANCH.

Mar. 22. "Plastic Moulding."

EAST MIDLANDS BRANCH.

Mar. 24. I.—Annual General Meeting.
II.—Short paper competition. (At Loughborough.)

LANCASHIRE BRANCH.

April. I.—Annual General Meeting.
II.—"Production Costs and Selling Prices," by A. Hodson.

PRESTON SECTION.

April 11. I.—Annual General Meeting.
II.—"Moulding Machines and Fettling Plant," by F. W. Neville, B.Sc.

LONDON BRANCH.

April 4. I.—Annual General Meeting.
II.—Short paper competition.

MIDDLESBROUGH BRANCH.

April 13. I.—Annual General Meeting.
II.—Further report of Technical Section.
III.—Short paper and general discussion.

NEWCASTLE-UPON-TYNE BRANCH.

May 24. I.—Annual General Meeting.
II.—Lecture: "How London's Tube Railways are Made."

SHEFFIELD BRANCH.

April 20. I.—Annual General Meeting.
II.—"Alloys in the Iron Foundry," by J. Roxburgh.

WEST RIDING OF YORKSHIRE BRANCH.

April 14. "Foundry Costs," by F. Whitehouse.

Autumn Meeting of the Institute of Metals.

An invitation has been extended to the Institute to hold its autumn meeting this year in Manchester, which the Council has accepted. With the object of forming Reception and Executive Committees to make the necessary local arrangements, a meeting of local members of the Institute is being held on March 20, at 2-45 p.m., in a room of the British Engine, Boiler and Electrical Insurance Co., Ltd., Fennel Street, Manchester. Dr. A. G. C. Gwyer, a vice-president of the Institute, will take the chair.

It is eleven years since the Institute last held its autumn meeting in Manchester, and it is intended by the Council, if possible, to arrange a general discussion on "Metal Melting," of which the autumn lecture will form a definite part.

Blast-Furnace Gas Cleaning

The First Two-stage Electrostatic Plant

The latest scientific method of cleaning blast-furnace gas operates on the electrostatic two-stage principle, by which the main bulk of the dust is removed from the hot, dirty blast-furnace gas, after which the gas is cooled with water sprays, and the small amount of dust remaining, along with water particles, is removed by a second group of electrostatic separators. A brief description of the first plant is given in this article.

IT is well known that the latest developments in the treatment of blast-furnace gas consist in cleaning by electrostatic methods on the two-stage principle. By this method about 97–98% of the dust is removed in the dry state from the hot dirty blast-furnace gas, say, at about 450° F., using chambers containing vertical earthed collector plates, between which are hung the discharge electrodes, connected to high-tension current supply at about 60,000–70,000 volts.

As a result, the dust particles are repelled to the collector electrodes, provided with rapping hammers to dislodge the material, and the gas, now only about 180° F., is reduced further in temperature in a slat cooling tower, and then passed to the second stage electro-filter, where all the

Showing the first Lodge-Cottrell electrostatic cleaning plant for blast-furnace gas operating on the two-stage principle at the Hochofenwerk, Luebeck (Germany).

suspended moisture and the remaining 2–3% of the total dust is removed. The final blast-furnace gas is of extremely pure quality, being dry, cold, and containing as low as 0·002 grains per cub. ft. (0·005 grms. per cubic metre), which is far below the usual gas-engine standard.

In this connection it will be interesting to make reference to the first plant installed a few years ago on these lines, using the "Lodge-Cottrell" system, at the Hochofenwerk, Luebeck (Germany), constructed by the Lurgi Apparatebau Gesellschaft, Frankfurt. It will be remembered that the "Lodge-Cottrell" system of electrostatic precipitation, originated by Sir Oliver Lodge and developed also prominently by Dr. F. G. Cottrell in the United States and Dr. Erwin Moeller in Germany, is controlled throughout the world by five firms who are working in close agreement—that is, Lodge-Cottrell, Ltd. (George Street Parade, Birmingham, and London), Western Precipitation Co. (Los Angeles), Research Corporation (New York), Lurgi Apparatebau G. (Frankfurt), and the Siemens Schuckertwerke A.G. (Berlin), while there are also other companies working the process on licence.

This first plant at the Hochofenwerk in Luebeck was started up towards the end of 1928, and much detailed information concerning its performance was published in Germany in 1931, being in the form of a special report of the Blast Furnace Committee of the Association of German Ironmasters.

The installation has a total hourly capacity of 1,412,600 cub. ft. (40,000 cubic metres) of blast-furnace gas, the original guarantee being to clean the gas down to 0·0074 grains of dust per cub. ft. (0·017 grms. per cubic metre), and a final temperature of 68° F. (20° C.). The hot, dirty blast-furnace gas passes through a bell valve into an evaporative cooler, where it is sprayed with cold water at about 140 lb. per sq. in. after cooling down to 185° F. (85° C.).

The gas is then cleaned in six electrical fields of a plate type of electrostatic cleaner, representing the first stage, through which it flows at a velocity of 2·9–5·9 ft. per sec. (0·9–1·8 metres). As a result, the dust content is reduced to 0·043–0·150 grains per cub. ft. measured at N.T.P.—that is, 0·10–0·35 grms. per cubic metre. Following this, the temperature of the gas is then reduced in a slat washer to 68–86° F. (20–30° C.), and although little dust is removed by the water, the content is reduced to below 0·065 grains per cub. ft. (0·15 grms. per cubic metre).

Finally, the gas, which contains a large amount of water particles, is treated in the second stage of the electrostatic cleaner, having three electric fields, and is reduced normally to less than 0·0004 grains per cub. ft. (0·001 grms. per cubic metre), which is far below the guarantee, while also the water particles have been removed.

Further, it was found in practice that the plant would deal very easily with 1,600,000–1,800,000 cub. ft. (45,000–50,000 cubic metres) per hour, instead of the designed figure of 1,400,000 cub. ft. (40,000 cubic metres). It has been proved that an important point also in addition to the great purity of the gas obtained is that the electrostatic principle is the most economical, and is particularly valuable because it is able to deal without difficulty with fluctuations and irregularities in the temperature, volume, and nature of the dust, which are characteristic of blast-furnace gas under average commercial conditions.

It is noteworthy that Lodge-Cottrell, Ltd., have now almost completed a large blast-furnace gas-cleaning plant on the two-stage principle for the South African Iron and Steel Industrial Corporation of Pretoria, while they have other important installations in course of erection at the Tata Works, Jamshedpur (India), and at Corby, near Kettering, for Stewarts and Lloyds, Ltd.

Tubes Ltd.

IN our reference to the exhibits of the above firm at the British Industries Fair, published in the February issue, a slight error occurred. It should have read, "among the special features are cold-drawn tubes for Admiralty boilers, locomotive boilers, and also cold-drawn steam-pipes. Special corrosion-resisting 'Resistco' tubes, alloy steel tubes for the chemical industries, cold-drawn oil-cracking tubes in straight carbon and alloy steels; tapered and swaged tubes for the motor industry; bush tubing, cold-drawn tubes for hydraulic lifts for the motor industry; and superheater and other tubes in special heat-resisting 'J' steel."

The Development of Materials for Poppet Valves

By C. C. HODGSON

The first part of this article reviewed briefly the subject of valve requirements, with special reference to the exhaust valve. In this article the author traces the development of the materials from which they have been made.*

A STEEL to make a satisfactory valve must have the necessary strength and toughness to prevent breakage at all temperatures up to the maximum attained in service, and it should be able to retain these properties for a period of time equivalent to the desired life of the part. To enable it to resist burning, the properties of the steel should also include resistance to corrosion, oxidation, erosion and wear, and the ability to retain permanence of dimensions after repeatedly heating to the maximum service temperature followed by relatively quick cooling. Most important of all, it must be reasonably adaptable to commercial methods of manufacture.

In the early days carbon steel, or 3% nickel steel, was generally used. A form of construction very successfully applied to certain slow-running engines was to use a cast-iron head on a steel stem, the head being attached to the stem by casting-on, by welding, or by screwing and brazing. As the requirements became more severe the need for a better valve steel was evident, and almost every steel available must have been tried at one time or another in the search for a more suitable material. Nickel steels containing from 1 to 5% of this element and nickel chromium steels containing up to 5% of nickel and 1.5% of chromium, both types having carbon contents ranging from the very mild varieties up to about 0.5%, offered quite a number of possibilities for experiment. The milder varieties of these steels were sometimes casehardened, whilst the same treatment followed by tempering was used with 3% nickel steel containing 0.3% of carbon, for the valves of one type of air-cooled engine. Chromium vanadium steels of the usual type were tried and also straight low-chromium and low-tungsten steels, as well as others containing both these elements in comparatively small percentages, and at least one silicon steel was used.

The first real advance came with the use of high-speed steels containing 14 to 18% of tungsten, and chromium steel of the stainless type. Both stainless and high-speed steels possessed properties at high temperatures markedly superior to any which had been tried previously. From this period onwards most valve steels contained much higher percentages of alloying elements than their predecessors, and attempted developments followed two distinct paths. On the one hand the aim was to develop an alloy having as nearly as possible all the desired properties of an ideal material, to a large extent disregarding the question of cost; whilst, on the other hand, the object was to produce steels simulating the properties of the first group but capable of being produced more cheaply.

Tungsten steels of the high-speed type were found to have good strength at high temperatures, and valves made from such material had a considerable vogue for use in hot engines, but as their resistance to oxidation was not particularly good they were superseded by other alloy steels of more suitable properties. The stainless steel used contained carbon in amount similar to, or somewhat higher than, the usual type of cutlery stainless, and later the silicon content was sometimes increased. Two examples of such steels will be found under reference numbers 1 and 2 in the table of valve steels accompanying this article. The table is by no means complete, but it gives some idea of the wide range of special valve steels; one or two of these have been of very infrequent occurrence, but all the examples quoted have been met with in practice by the writer, with the exception of those containing aluminium.

The stainless steels were found to have a resistance to scaling at temperatures up to 750° or 800° C., far in advance of the carbon or low alloy steels formerly used. Their tensile strength at high temperatures did not differ greatly from those of the more usual types of low alloy steels. In the matter of hot tensile strength the carbon content has a considerable influence on these 12 to 14% chromium steels. For example, a steel of this type containing 0.3% carbon possesses at 800° C. almost twice the strength of the so-called stainless irons of low carbon content; for this reason the amount of carbon present was often of the order of one half of 1%. Some slight further improvement in this respect was obtained by the use of still larger additions of carbon, and the steels containing as much as 1.5% of this element were regularly used (No. 3), whilst experiments were even made with steels containing as much as 2%. Increasing the carbon content affected the resistance to scaling somewhat adversely.

VALVE STEELS.

Steel No.	C.	Si.	Mn.	Cr.	Ni.	W.	Co.	Mo.	Al.	V.
1	0·32	0·21	0·40	13·50	—	—	—	—	—	—
2	0·40	0·93	0·37	13·20	—	—	—	—	—	—
3	1·55	0·18	0·22	11·30	—	—	—	—	—	—
4	1·40	0·51	0·40	12·50	—	—	3·70	0·75	—	—
5	1·60	0·15	0·15	11·30	—	—	—	0·91	—	1·07
6	0·35	3·20	—	13·00	—	—	—	—	—	—
7	1·20	4·20	0·40	11·50	—	—	—	—	—	—
8	0·61	0·35	0·38	7·10	—	—	—	—	—	—
9	0·58	1·50	0·44	6·60	—	—	—	—	—	—
10	0·51	1·51	0·53	7·62	—	—	—	—	—	—
11	0·48	3·33	0·45	8·30	—	—	—	—	—	—
12	0·40	3·19	0·48	8·55	—	—	—	—	—	0·40
13	0·45	3·10	0·69	8·20	—	1·56	—	—	—	—
14	0·47	3·90	0·45	2·80	—	—	—	—	—	—
15	0·53	0·56	0·19	6·30	3·30	—	3·60	0·97	—	—
16	0·42	1·50	0·65	13·00	12·90	2·20	—	—	—	—
17	0·42	2·44	0·89	11·30	12·75	2·60	—	—	—	0·50
18	0·33	1·42	0·60	17·80	7·90	3·50	—	—	—	—
19	0·35	1·68	0·40	22·00	9·10	2·90	—	—	—	—
20	0·57	0·72	0·26	15·70	21·60	3·20	—	—	—	—
21	0·46	1·56	1·25	14·70	27·10	3·20	—	—	—	—
22	0·43	2·55	0·43	16·60	26·50	—	—	—	—	—
23	0·31	2·66	0·32	13·40	8·37	—	—	—	—	—
24	2·24	0·53	3·80	7·50	22·90	—	—	—	—	—
25*	0·42	0·42	—	9·73	—	—	—	—	1·98	—
26*	0·40	1·02	—	10·56	1·39	—	—	—	1·99	—
27*	0·47	2·22	—	9·10	—	—	—	—	2·12	—
28*	0·45 to 0·60	1·0 to 2·0	0·65 Max.	7·0 to 9·0	—	—	—	0·4 to 1·0	0·25 to 1·0	—
29*	1·03	1·03	—	17·92	—	—	—	—	2·25	—
30*	0·44 to 0·52	0·75 to 0·95	0·50 Max.	10·0 to 10·9	1·4 to 1·75	—	—	—	1·7 to 1·9	—

* E. F. Davis.

Another steel of this group was the chromium cobalt steel (No. 4), either with or without a small percentage of molybdenum. Opinion seems to be divided as to whether this steel had any real advantages over a similar one without the cobalt addition, but the fact remains that it had a considerable reputation and was quite widely used. Steel (No. 5), which was used experimentally, is a further modification of this group. All these higher carbon chromium steels had good resistance to stem wear. The presence of a considerable percentage of chromium had the added advantage of raising the temperature of the carbon change-point on heating, thus allowing the valves to operate at a higher temperature without air hardening and so reducing the danger of crack formation and distortion sometimes associated with air hardening.

* *February Issue, p.p.* 113–114.

The outstanding achievement in the development of the nickel-free heat-resisting steels was the discovery of the effect produced by the addition of considerable amounts of silicon in conjunction with chromium. It was found that such additions, usually of the order of 2.5 to 4% silicon considerably extended the range of temperature over which a satisfactory resistance to scaling existed, whilst at the same time the rate of oxidation was greatly reduced. Silicon, like chromium, raises the AcI critical temperature, only in a more marked manner, so that silicon chromium steels can be heated to a still higher temperature without air hardening on quickly cooling than the straight chromium steels of similar chromium content. One of the first of the silicon chromium steels contained 3–4% silicon and 8–9% chromium with about 0.4% carbon. After more than ten years this steel, with or without slight modifications, remains the best and most popular of the silicon chromium group, (No. 11). It resists scaling to a remarkable degree, but does not possess any considerable strength at high temperatures. Slight modifications are sometimes made by the addition of other elements such as tungsten or vanadium as in the examples Nos. 12 and 13. The chief improvement, however, has been a better understanding of the forging and heat-treatment requirements to develop the optimum mechanical properties.

Fig. 5—Cast valve showing shrinkage cavities.

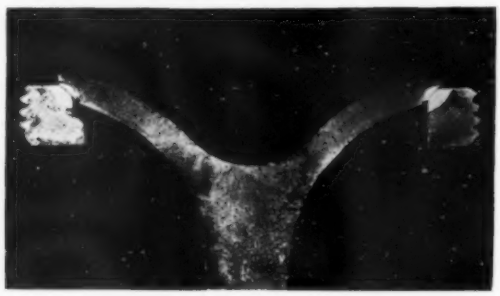


Fig. 6—Section through valve and insert, both faced with Stellite.

In addition to the 13% chromium and the silicon chromium steel just discussed, a large number of chromium and silicon chromium materials of varying analyses has been used. Nos. 6 to 10 and No. 14 are examples of some of these. It will be seen that Nos. 6 and 7 are similar to the 13% chromium steels already discussed, but with the addition of ¾% silicon. A group having a higher carbon but lower chromium than the cutlery stainless will be noticed under reference Nos. 8 and 10. The silicon varies from nominal amounts up to 2%, and small amounts of other alloying elements are sometimes added (No. 10). A cheaper steel, which has been rather widely used, will be noted under reference No. 14. With such a wide range of analyses it will be readily understood that the properties of the extreme members show considerable differences. The silicon chromium steels of the better types, whilst leaving very little to be desired in the matter of resistance to oxidation, lack one essential property for really high temperature work, namely, hot strength. At temperatures in the region of 800° C. this is definitely inferior to some of the earlier valve steels, such as high-speed and cobalt chrome steels. If valves have to operate at very high temperatures the use of silicon chromium steel has been found to render them liable to fatigue failure in the neck as a result of this low strength.

Some of the high nickel chromium austenitic steels possess in an outstanding degree the property of retaining good strength at high temperatures. From such alloys a number of very successful exhaust-valve steels has been developed. Some of these are not only the strongest materials available but also the most resistant to oxidation. In respect to the latter, however, the various members of the group vary considerably, some of them being slightly inferior to the best silicon chromium steels. Taken all round, however, they represent the best wrought materials available for service at high temperatures. The nickel content ranges from about 7% to 30%, and the chromium from 10% to 25%. Appreciable amounts of silicon are usually present, as it has been found that this element very much improves the resistance to oxidation. In this country some tungsten is usually added with the object of still further increasing the hot strength. Examples of a number of these steels will be found under reference Nos. 16 to 23. Of these Nos. 16, 18 and 21 have been widely used in this country; No. 23 has been used to a considerable extent for aircraft engine valves in the United States. Strictly speaking, this is not an austenitic steel, for it may be made either austenitic or martensitic by the use of suitable heat treatments.

The coefficients of expansion of all the austenitic valve steels is high. This is unfortunate, as it means that larger clearances must be allowed. When the stem clearance is correctly adjusted for the maximum operating temperature it follows that the clearance at lower temperatures will be too great, and under certain conditions undue wear of the seat which this increased play allows may lead to premature failure by burning as a result of gas leaks. Another disadvantage of these steels is that the resistance of the stem to wear is not particularly good when operating at rather high temperatures. To improve this some of the valves are now nitrided on the stems. Similarly, the thermal conductivity of the austenitic steels is rather poor, and this applies in a lesser degree to all the high alloy valve steels. This causes the valve heads to run hotter than would otherwise be the case. Despite their shortcomings these steels include the best all-round materials available for use under the most exacting conditions of service.

Alloy No. 15 is an example of what may perhaps be termed intermediate steels for want of a better name; such steels have made their appearance from time to time. Whilst alloy No. 24 is one which was used to a limited extent in the cast state, the valve being cast to shape and used in the " as cast " condition, one danger with this type of valve was the possibility of weakness in the neck from internal cavities formed during solidification. A cast valve made of an alloy of this type is shown in section in Fig. 5. This is an excellent example of the kind of defect which may be present without any surface indications of its presence.

Aluminium can be used to replace some of the silicon in certain steels intended to resist oxidation. A. L. Boegehold and J. B. Johnson state that a steel containing carbon 0.46–0.56%, chromium 10.5–11.5%, silicon 0.9–1.1%, nickel 1.2–1.5% and aluminium 1.75–2.1% may be substituted for a silchrome steel containing carbon 0.38–0.45%, chromium 9.0–9.7%, silicon 3.25–3.75% with good results. Such steels do not appear to have been used in this country for valves, but according to E. F. Davis they have been quite widely used in America; some of the types quoted by Davis will be found under reference Nos. 25 to 30.

There is no best valve steel if by this term it is intended to imply that only one steel, or class of steel, would be used were it not for questions of cost or ease of manufacture. The ideal exhaust valve material has not yet been evolved. All the existing steels are deficient in one or more desirable

qualities. The final choice must depend on the shape and proportions of the valve and the general conditions under which it operates. As an example may be quoted medium carbon stainless steel, from which large numbers of valves were at one time made. This steel gave considerable trouble in a certain 12-h.p. engine, and valves made from it had to be replaced regularly every 10,000 to 12,000 miles due to "burning". Other valves of the same type of steel have been found to be in almost perfect condition after 80,000 to 100,000 miles in a two-ton lorry engine. The best valve steel is that which gives efficient service at the smallest first cost.

For conditions where strength is required at high temperatures the austenitic steels are pre-eminent. For best resistance to burning and scaling the better types of silicon chromium steels and some, though not all, of the austenitic steels would be chosen. The high-carbon chromium steels offer the greatest resistance to stem wear. Other physical properties which might be expected to be of interest in connection with valve steels are coefficient of expansion, thermal conductivity, and specific heat. A coefficient of expansion considerably lower than that of ordinary cast iron or steel would be an advantage, as this would enable the clearance in the guides to be kept more nearly constant during running; no such valve steel exists.

The stainless type has a value slightly lower than that of ordinary steel of similar carbon content, whilst the coefficients of the various silicon chromium steels are about the same as, or slightly higher than, carbon steel. One disadvantage of the austenitic steels is their high rate of expansion, the coefficients being roughly from one-quarter to one-half as much again as ordinary medium carbon steel. The thermal conductivities of all the special valve steels are considerably less than those of carbon steel; between the austenitic and the chromium silicon classes the advantage is with the straight chromium and silchrome steels. The specific heats of the various valve steels do not differ greatly from those of carbon or low alloy varieties.

In practice most of the demands can be met by selecting a suitable grade from the modern types of valve steels, but it seems doubtful if existing steels will be able to meet unaided further demands which special conditions of service are likely to make. Within the last few years petrols containing comparatively large additions of ethyl fluid have sometimes been used for aero engines. The products of combustion from such fuels are somewhat corrosive, and under these conditions the problem of corrosion is added to those already existing. A method of improving the resistance of the valve seat to wear and corrosion is to make this part of an alloy better adapted to meet the conditions than the valve steel itself. Considerable progress has been made in this direction by welding a thin layer of stellite on to the valve seat. The method is not new; it was used to a limited extent in America ten years ago; but it is only recently that it has received general attention. In principle it is a return to the old composite valve using a cast-iron head on a nickel-steel stem. Perhaps the most satisfactory results will be obtained by treating both valve and insert in this way, using a soft grade of stellite having a diamond pyramid hardness number of about 400 for the valve seat face and a harder alloy with a diamond hardness number around 600 for the face of the insert; although stellite of this hardness is somewhat brittle this should cause no difficulty provided suitable methods are used for fitting the insert to the head. A section through a valve and insert, both of which have been treated in this way, is shown in Fig. 6. The parts have been etched to show up the facing materials.

The high temperature at which the valve operates is the cause of nearly all its troubles, and it is only natural that attempts should have been made to assist in valve cooling. Some of the methods used to this end were indicated in the first part of this article. At the present time it is too early to state how far the copper cored valve will go towards solving the problem, but the hollow valve stem partly filled with metallic sodium appears to be a very attractive proposition. By this means it may be possible to use steels which would not otherwise meet the requirements. For example, silchrome by running cooler would be stronger and might be used in place of the stronger austenitic steels in engines where these have previously been required. Valves may be forged in such a way that the heads as well as the stems are hollow for the purpose of internal cooling, but as the heat removed from the head is transferred to the stem, questions of stem wear and clearance would appear to set a limit to the amount of cooling which can be successfully applied to the head in this manner. Internally cooled valves used in conjunction with heat, wear, and corrosion-resisting seats and inserts seem to represent the present trend for valves intended for the highest duty.

Increasing the efficiency of the valves by methods similar to those just discussed naturally adds to the cost of the finished article, and it is interesting to speculate on the effect which this may have on future development. Will this stimulate the search for a material that will enable a return to the simple one-piece valve? Or will questions connected with engines of increased power output demand a cooler valve irrespective of the properties of the material from which it is made? Experiments suggest that there is little doubt that a valve could be made in an alloy—not necessarily mainly ferrous—having hot strength equal to that of the best modern valve steels, a resistance to corrosion and oxidation at least as good as the present facing materials and capable of selective hardening where required, but whether valves of such a material could be produced at a price to make them commercially attractive would have to form the subject of a considerably more intensive study than has been made at present.

Corrosion by Sea and Ozone.

A USEFUL innovation for engineers and manufacturers who wish to conduct practical tests on the immunity of paints, metals, and other products from deterioration due to the action of sea water, sea air, ozone, and sunlight, is the opening of a testing station at Mersea Island.

An independent means is thus provided of carrying out much more exhaustive and rigorous tests than the usual method of spraying specimens with sea water in a closed chamber. The latter method, however conscientiously employed, is inconclusive for several reasons. In the first place, the specimen is more or less at the same temperature throughout the test, a serious objection in the case, for instance, of a paint which under working conditions may cover a metal that itself expands and contracts under differing temperature conditions. Also, the sprayed salt solution usually remains at constant strength, whereas under working conditions when sea splashes on to a material the sun evaporates the water, leaving dry salt which may subsequently be washed into cracks or pores in the form of a more concentrated salt solution. The possible disintegrating effects of the sun and of ozone, one of the most destructive gases associated with sea corrosion, are also not usually represented in artificial methods of testing.

The mud flats off the Essex coast, covered by the sea at each tide, provide an ideal site for testing all marine corrosive actions. At the Mersea Island Testing Station specimens under trial normally are placed so that at high water they are immersed in the sea for periods of between one and two hours; when the water recedes they are exposed to the sun and wind and later to the ozone released from the mud by the sun.

The station was originally started by Mr. F. E. Robinson, of the Marconi Company, to test materials and component parts for apparatus manufactured at the Company's Chelmsford Works. By consent of the Marconi Company, the scope of the station has now been extended and in future it will be conducted as an independent testing station under the supervision of Mr. L. M. Robinson, Assoc.M.Inst.C.E. Its services will be at the disposal of public authorities and engineers who desire an independent report on materials, or manufacturers who wish to have their products tested under natural conditions.

Reviews of Current Literature.

The Casting of Brass Ingots.

WITH the rapid development of technical research there has been a tendency to overlook fundamental factors upon which the success of subsequent work is almost entirely dependent. No more important study in the metallurgical field, for instance, is that of casting ingots, yet it is only during comparatively recent years that careful attention has been directed to the problems associated with their sound production. The casting of an ingot is obviously a vital stage in the manufacture of wrought metals, for whatever improvements in quality or economies in working may be effected in later operations, perfection cannot be achieved if the original ingot is faulty. Like the five weighty reports already published by the Heterogeneity of Steel Ingots Committee, whose work is still continuing, this book is evidence of increased interest now taken in the quality of ingots intended for working into rolled or forged products. It makes available in an accessible and readable form the experience accumulated by the authors during the conduct of a thorough research into the factors affecting the surface quality and internal soundness of brass ingots.

The book opens with an historical chapter tracing the history of brass and brass manufacture from the earliest times up to the present day, based on a survey of original sources of information. Commercial casting practice as it existed in England in 1921, is described in the second chapter of the book, together with those developments, including the introduction of electric melting furnaces and water-cooled copper moulds, which have taken place in the industry since that date. There follows an exhaustive account of the defects commonly occurring in brass sheet and rolled strip. The causes of these defects are analysed and traced back to defects in the original cast ingot.

The major portion of the book describes a detailed experimental analysis of the casting process. The properties of the liquid metal, the method of formation of the ingot from the stream, and the method of solidification of the cast ingot are first considered. This part of the book, dealing with the formation of the ingot, is concerned mainly with an examination of the influence of pouring conditions on the internal soundness and structure of the ingot. Various factors involved in the casting process, and the directions in which they influence the soundness and surface quality of the cast ingots are then considered in detail. Most important among these factors are casting temperature, speed of pouring, feeding, dimensions of ingot, mould conditions, mould coating, position of mould during casting, and dissolved gases. The effects of these factors are discussed in relation to the casting methods used in modern commercial practice, and various modifications are suggested for improvement of the quality of the cast ingot.

An important section is devoted to a consideration of materials for moulds. Cast iron has been almost universally used for this purpose for many years, and the authors discuss the nature and cause of some of the difficulties experienced with cast-iron moulds and suggest more satisfactory alternative materials.

While the bulk of the work discussed applies to ingots cast by normal commercial pouring methods, special casting processes which have recently been devised are fully considered, and a separate chapter is devoted to a discussion of the principles and practical utility of the Durville process, the Erical process, and bottom casting in relation to non-ferrous metal manufacture.

The book concludes with a number of appendices, Appendix A dealing with the rolling of brass sheet and strip, Appendix B with the constitution and density of the industrial brasses, and Appendices C and D with the aluminium brasses and the phosphorus brasses respectively. While the book does not make any attempt to discuss in detail the physical and mechanical properties of the brasses, the addition of aluminium or phosphorus has beneficial effects in certain casting methods, and it is necessary when considering such additions to discuss the marked effect of small amounts of such elements on the properties of the basis alloy.

This is the third Research Monograph of the British Non-Ferrous Metals Research Association, and although it deals primarily with brass ingots, the ultimate value, and of the work which underlies it, is not confined to the practice of brass casting, since the principles which have been established are in many cases equally applicable to the casting of other metals. The book should therefore be of great value to all who are interested, directly or indirectly, in metallurgical practice. It is admirably prepared and well illustrated, and is a very worthy contribution to an important subject.

By R. GENDERS, M.B.E., D.Met., F.I.C., and G. L. BAILEY, M.Sc., with an introduction by Dr. H. MOORE, C.B.E. Published by the British Non-Ferrous Metals Research Association, Regnart Buildings, Euston Street, London, N.W. 1. Price 15s. (postage 6d.).

A.S.T.M. Tentative Standards, 1933.

THIS annual publication of the American Society for Testing Materials contains all tentative specifications, methods of test and definitions of terms issued by the Society, covering engineering materials and the allied testing field. Although in the trial stage of standardisation procedure, these tentative standards, embodying the latest convictions and practices, find important application and are widely used in industry. The 1933 edition contains 223 tentative standards. Of these 47 are published for the first time, while some 41 were revised in 1933 and are given in their latest approved form. New tentative standards which were published in 1933 for the first time cover the following ferrous and non-ferrous materials :—Steel for bridges and buildings (60,000–72,000 grade) ; mild steel plates (55,000–65,000 grade of steel) ; high tensile strength carbon-steel plates ; alloy-steel and carbon-steel castings ; elliptical springs ; lap-welded and seamless steel pipe for high-temperature service ; zinc coating on hardware and fastenings ; wrought-iron rivets ; and magnesium ingot and stick for remelting. New tentative test methods include the impact testing of metallic materials, short-time high-temperature tension tests, and " creep " tests.

Included in the list of widely used materials covered by revised tentative specifications and test methods are the following :—Aluminium, aluminium-alloy (duralumin), and aluminium-manganese alloy sheet and plate ; zinc-base alloy die castings ; metallic materials for electrical heating (chemical analysis) ; clay sewer pipe ; coke (sampling for analysis) ; calcium chloride ; asphalt roll-roofing ; insulated wire and cable ; and textiles (test for identification of fibres and quantitative analysis).

In addition to all of the A.S.T.M. tentative standards the 1933 edition of this book gives proposed revisions of standards, which are published tentatively to elicit criticism before final adoption. Changes in 46 standards have been proposed. It has a complete subject index, and two tables of contents, designed to facilitate the use of the book, one listing the items under the general materials covered, the other in numeric sequences of their serial designation.

The publication contains 1,136 pages. Copies in cloth binding at $8.00 each, or in heavy paper cover, $7.00, can be obtained from A.S.T.M. Headquarters, 260, South Broad Street, Philadelphia, Pa., U.S.A.

Manufacture of Seamless Tubes.

A BOOK dealing exhaustively with the manufacture of seamless tubes of ferrous and non-ferrous metals will be available shortly. The author, Mr. Gilbert Evans, analyses and describes minutely each progressive stage of manufacture, from the solid billet to the hot- and cold-drawn finished, seamless tube. It will be published by H. F. & G. Witherby, 326, High Holborn, London, W.C.1.

Repairs to Steel Furnaces

By Walter Lister

A method of burning-in the bottom of an open-hearth furnace is described and important factors necessary to a successful repair are stressed. Different materials are discussed for both acid and basic furnaces

BURNING-in the bottom is the best method of repairing an open-hearth furnace, but it requires a long time and great care to make it a success. In preparing the furnace for this method, I have found it best to shape the hearth by brickwork, as shown in Fig. 1. This saves a lot of time, and is quite safe, as it is not necessary to have a great thickness of dolomite at the ends, a medium thickness well burnt and fritted solidly together is much better than great thickness only half fused. Contrary to the case of the rammed bottom, the furnace need not be dried

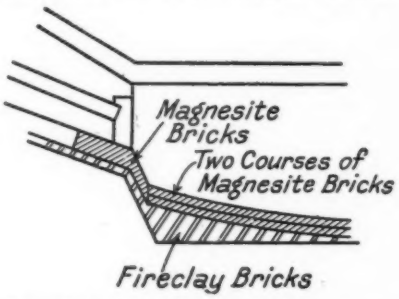


Fig. 1.—Showing how the bottom is shaped before burning-in.

by means of coke fires, but wood fires and then gas can be put in as soon as all repairs are complete. Before this is done, however, the tap-hole opening should be rammed solidly with ramming mixture.

When the furnace has attained a good white heat, and not till then, start on the bottom at the tail end of the gas, using fresh, well-burnt pea-size dolomite as free from dust as possible. Put a very thin layer on, so that at the end of the half hour, when reversing is due, it will be well fused. Reverse the gas, and put a layer on the other end, taking care to spread it evenly all over the bottom. At the end of the half-hour, this ought to be fused, when the operation can be repeated at the other end. By proceeding in this way, the bottom can be built up methodically and without loss of time, and the best results possible will be obtained. The main precaution to observe is to put only as much on at one time as will fuse well in the half hour during which the gas is on one end, and always work at the end which is hottest—namely, where the gas is leaving.

If too much material is put on, it is impossible to fuse it in the half hour, if the gas is reversed at the proper time it stands little chance of fusing under the gas coming in, and if the gas is kept on one end longer than the usual time, the chambers at that end will become colder, and there will necessarily be a shortage of heat next reverse, and so on; from which it will readily be seen that a proper system must be strictly adhered to and faithfully carried out with patience and intelligence in order to get the best results. Every layer of dolomite put on should be tested with a rabble. If in proper condition, it should be hard, and just a little "slimy," so that it will stick to the edge of the rabble head. As the work progresses, the bottom will be sloped and the banks taking shape.

When a level near to the bottom of the tap-hole has been reached and the bank above the tap-hole has been given about the required thickness, cut out the tap-hole very carefully by means of a sharp bar. When the tap-hole has been cut through, it will be seen exactly how much more dolomite is required and where, and this can be placed accordingly. If the tap-hole is found to be short—that is, the bank not sufficiently thick—put a long iron pipe up of the proper diameter, and projecting as far into the furnace as required, and build the bank round it, using dolomite mixed with tar. Light a fire in the lander, and when the ramming has sufficiently set, the pipe can be withdrawn. Continue the fire in the lander, and allow the flames to pull through the tap-hole until the whole is burnt hard and compact.

If, after cutting out the tap-hole with the drill, it is found of sufficient length, it will not be necessary to use a pipe; all that is required is a wooden template of the necessary length with which to finish off the tapping side, if necessary by means of the ramming mixture. Later, this plug will burn out when the tap-hole can be hardened with a fire as before. When the work is completely finished, the tap-hole should be closed and the bottom well slagged. Roughly ground slag should be thrown all over the bottom and banks, and allowed to melt. A lot of it will soak in, but, after repeated dressings, a pool will form on the bottom. This should be tapped out, and the tap-hole closed again, after which the furnace will be ready for charging.

Hearths put in by this method are by far the most durable, and with proper attention will last in good condition for an average life of four years. On the other hand, if carelessly made, they may not last four months.

Banks Thin at the Top.—The only drawback to burning in a furnace hearth, and it applies to acid as well as basic furnaces, is the fact that there is always difficulty in making the top of the banks of the required thickness. The usual practice is to throw dolomite up in the hope that it will stick in the right place, but the usual result is that the majority of it runs down to the bottom and thickens there more than is desired. If the dolomite is put in with a fettling shovel the same thing happens, and the bank remains thin at a dangerous point. The remedy usually adopted is to keep the charge down a ton or two, but this seriously reduces the output. The best thing to do when the hearth is to be burnt in is to build up the magnesite walls two courses higher and then make the hearth up to this. The top of the banks will then be well above the level of the door sills and the slag line will be at a safer thickness. This is illustrated in the sketch, Fig. 2. At the point A the bank is dangerously thin, but at B it is a safe thickness.

A Magnesite Hearth

An alternative material to dolomite is magnesite, and hearths made of this material give good service, but only under certain conditions. They must be burnt in, not rammed or bricked, and only used with cold charging processes. If an attempt is made to ram them in by hand it will be found that only a thin layer ever gets properly fused; it is far too refractory to burn in bulk, and consequently when once a hole develops and steel penetrates the thin crust of fused bottom, trouble never ceases, and the men are kept constantly washing out and repairing, with much loss of time and production. A rammed dolomite bottom never gets properly fused for more than half its thickness, but a rammed magnesite bottom is much worse in this respect.

If the hearth is put in with magnesite bricks and a covering of pea-size magnesite, either rammed or burnt on, it is not satisfactory. In the first place, it is very costly, and in

the second place the covering layer would leave the bricks, which would chip and fall to powder under a high temperature.

The best and only way to put in a magnesite hearth is to burn it in, and this must be done very carefully and slowly. It cannot be fused in its pure state at furnace temperatures. It has therefore to be mixed with small proportions of silica and lime in order to cause it to bind or frit into a solid mass. It may be thought that magnesite containing these proportions of silica and lime as part of its composition would be ideal for the purpose, but in practice it is found not to be so. It is better to use the best and purest magnesite obtainable and mix it before use with the necessary amount of flux. In this way every separate grain of magnesite has a cement of flux around it, binding the whole into a solid and compact mass.

To commence operations, grind in a mill a mixture of two parts of lime and one of silver sand. Make a quantity of this mixture, and make sure that it is intimately mixed. Empty a few bags of magnesite on to the platform in front of the furnace and mix it well with 5% of the lime and

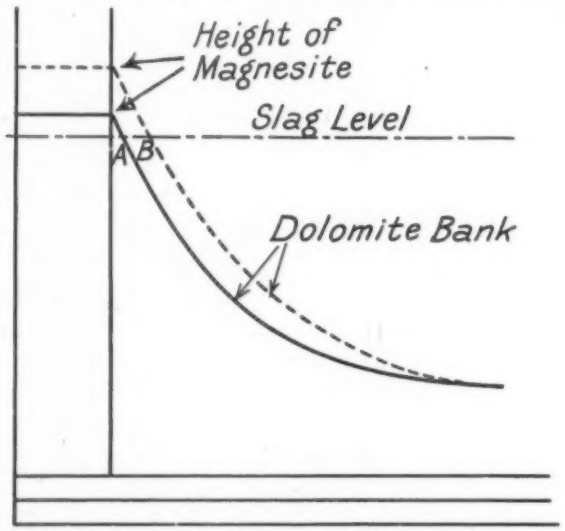


Fig. 2.—Showing the advantage of a higher magnesite wall.

sand mixture. It is very important that it should be well mixed. The best way to do it is to put 20 shovelfuls of magnesite in a heap and then sprinkle one shovelful of the mixture over it. Then 20 shovelfuls more of magnesite and one of the lime and sand mixture, and so on till sufficient for immediate requirements is made. Then commence turning the heap over, and turn it over two or three times until the whole is most intimately mixed. Too much importance cannot be attached to the mixing; it is not sufficient to throw a bit of lime and a bit of sand over a heap of magnesite and expect it to make a good bottom; the sand and lime must be mixed separately first and in the proper proportions, and this cannot be done properly except in a mill; and the whole mixture of magnesite and flux must be very carefully and conscientiously made up. Haphazard methods lead only to trouble, and they are always the longest and most costly in the long run.

Method of Procedure.—We will assume that the furnace is at a good white heat, and that a good supply of magnesite is prepared and conveniently handy in front of the furnace. As in the case of the dolomite bottom, the tap-hole opening has been previously rammed solid with ramming mixture (half dolomite and half magnesite). Proceed exactly with the magnesite as with the dolomite, spreading a thin layer on the bottom and at each end alternately, taking care that only just sufficient is put on each time as will fuse during each reverse. As the magnesite will be found to be more refractory than dolomite, it is best to allow a full half hour after the last of the magnesite has been thrown in. The tap-hole is made as described for a dolomite bottom, but using magnesite instead of dolomite, but always ram the tapping side with 50% dolomite and 50% magnesite mixed with tar, as you will never get magnesite alone to harden properly: it generally crumbles away as soon as the support is taken out. It is preferable to use a proportion of finely ground magnesite in the mixture for ramming the tap-hole, as this forms a more plastic mixture, which stands up better in ramming, and will not fall away like the gravel size material alone.

General Remarks.—As I have said before, magnesite bottoms are satisfactory only up to a point. It is when hot metal charges are used, and the charge consists of 90% or more molten iron, that trouble commences. They will not stand any large amount of ore being put on the bottom. With all hot metal processes except the Talbot, a most important feature is to charge ore and lime on the bottom and have it well warmed up before the molten iron is poured in. This large quantity of ore has a very corrosive effect on the magnesite hearth, and very soon large holes develop which defy all attempts at satisfactory repairs, one hole succeeding another in rapid succession. After almost every charge there is bottom trouble, boils in the breast and boils in the banks, always danger of a break-out, until the whole staff are weary and worn with anxiety. There is not sufficient time in between casts to properly fuse in further additions of magnesite, and so holes have to be repaired with dolomite. The result is that very soon half the bottom is dolomite, mixed with a large proportion of steel.

To sum up, magnesite bottoms are not worth the expense incurred; they are perhaps a little more durable than dolomite bottoms for cold scrap and pig charging, but for hot metal (90% or more molten iron) they are totally unsuitable, and in all cases that I know of where they have been installed, they have been very soon gladly taken out in favour of the cheaper and better material for the purpose —namely, dolomite.

Ramming an Acid Hearth

The material used for ramming an acid hearth should be good ganister stone mixed with a little fireclay, usually in the proportion of 10 to 1. They should have approximately the following composition:—

—	Silica.	Alumina.	Oxide of Iron.	Lime.	Magnesia.	Alkalies.	Organic Matter.
Ganister	95·32	1·26	0·86	Trace	Trace	Trace	2·56
Fireclay	65·47	30·15	2·85	0·70	0·40	0·31	Trace

This mixture should be finely ground and mixed well together, with just enough water to make it plastic.

In the case of an acid furnace, of course, there are no magnesite bricks required, the bed of the hearth being made with fireclay bricks and the walls of silica bricks only. After carefully drying with coke or coal fires, and sweeping out clean, the ganister should be carefully rammed all over, a thin layer at a time, using the templates in order to obtain the necessary thickness and slope. The bottom should be given the minimum thickness of 6 in., and the sides rammed to a height of about 3 ft., reaching at the ends to about 2 in. below the bottom of the gas ports. The banks at the top should be about 4 in. thick.

Making the Tap-hole.—Ram the tap-hole round a wooden plug or template the size required, usually about 3 ft. 6 in. × 6 in. × 4 in. This plug should be set at about the same slope as the lander. For ramming the tap-hole, use a mixture of 15 parts ganister to one of fireclay.

Drying the Bottom.—After ramming, it is very important to dry the bottom well before gassing, by means of a slow wood or coal fire. Keep the chimney damped down for the first two hours, and then raise gradually a little more each hour until full open. If not perfectly dry, steam is likely to accumulate and lift it up. I have seen lots of rammed bottoms lifted up in this way, which means doing the work all over again. Keep fire in for three days.

When the furnace has got gas and the temperature is sufficiently high—a good white heat,—finish with good silver sand, Belgian for preference. There may be a few cracks showing in the ramming, but these can all be filled up and the bottom consolidated in the finishing. Put on just a light coating each time, each end alternately, and allow each layer to fuse in before adding another, until a depth of about 3 in. is obtained. When completely finished, the tap-hole should be closed and the whole of the bottom and banks well saturated with clean ground acid slag. The whole operation of ramming, drying, warming up, and finishing off should not take more than eight or nine days.

Fusing in an Acid Bottom.—First of all, ram the tap-hole opening hard and solid from the inside with good ganister, the opening outside being temporarily closed with a piece of plate wedged against the tap-hole casting. After gassing, and when the furnace is at a good white heat, taking usually about three days, the operation of making the bottom can commence. For the first coat or two use a second quality sand, mixed with loam in the proportion of 1 in 20. This is advisable because it is almost impossible to get a sufficiently high temperature in the bottom and corners to get highly refractory sand to frit well. Commence by filling the corners up, and cover the bottom with this less refractory mixture. When about 2 in. of this material has been put in, commence using second quality sand without any loam. Gradually slope the ends and the walls, at the same time shaping the hearth, allowing a gradual fall from all parts to the tap-hole. Do not put too much on at once—a thin layer at a time, and well fused in. Test each layer with a rabble before adding another. A little of the fused sand should stick to the edge of the rabble head when given a downward blow on to the hearth. Make sure of this, as it is much better to take a longer time and have a good bottom than to hurry the job and have continual trouble. Everything depends on the sand being well fused, hard, and compact. Put on about 3 in. with second quality sand, and the remaining 5 in. with first quality sand. Before the bottom is finally completed, open out the tap-hole with a sharp bar. On seeing this, you will have some idea how much more there is to go on, and how the bottom is shaping generally. When you see where the tap-hole is, you can finish off the bottom accordingly.

This method will take slightly longer than ramming, from gassing to completion of the bottom usually occupying about ten days.

ANALYSES OF SANDS AND LOAM.

—	Silica.	Alumina.	Oxide of Iron.	Lime.	Magnesia.	Alkalies.	Organic Matter.
1st Quality	97·65	0·80	0·56	0·20	Trace	0·15	0·84
2nd "	85·77	2·30	0·47	4·30	0·91	0·60	5·30
Loam.....	85·06	5·47	3·10	1·90	0·96	0·30	3·00

Hearth Mixtures.—Well-known mixtures for burning in acid hearths that have given good results are :—

1. Red sand ..... 1 part.
   Belgian ..... 8 parts.
2. English (Aylewood) 50%
   Belgian 50%

Before using, all sand should be well calcined in a small reverberatory furnace, in order to burn off any organic matter and expel water.

Crushing of Limestone

The "Kennedy" vertical gearless drive gyratory crusher, which is briefly described in this article, embraces some striking features. The machine will crush extremely hard material such as limestone, granite, nodular limestone, and similar materials, and will give continuously a crushed product of any desired size, always in the cubical condition.

THE main requirements of an efficient crusher for limestone, ironstone, and other hard material in the iron and steel and general metallurgical industries include low wear and tear and maintenance costs, simple design, low power consumption per unit capacity, noiselessness, and rapid adjustment of the machine for changing the size of the product. It is claimed all these good points are possessed by the "Kennedy" vertical, ball bearing, gearless, gyratory crusher, manufactured by the Sheepbridge Coal and Iron Co., Ltd., Chesterfield.

General view of the "Kennedy" crusher ("S" type) built by the Sheepbridge Coal and Iron Co., Ltd.

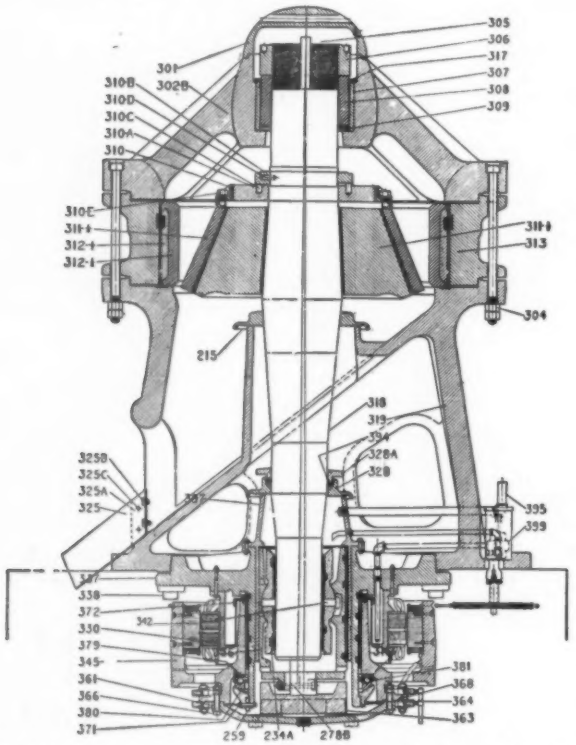
Essentially the design consists in the use of a relatively short vertical, heavy steel spindle or shaft, carrying a manganese steel crushing cone which is caused to move continuously in gyratory fashion within a manganese steel stationary throat, forming the crushing space—that is, the vertical shaft does not normally revolve on its own axis, although free to do so, but moves in gyratory fashion about a fulcrum at the upper part of the machine, above the crushing space. This vertical shaft also is threaded at the top and provided with a deep adjusting nut from which it is suspended, the nut resting on an upper spring plate. Under the latter are a series of powerful springs, resting on a lower spring plate, supported in turn from the main casting of the machine by a suspension ring. At this point also the top of the machine is provided with a heavy two-armed steel spider, cast in one piece with the ring, highly arched to allow uniform feeding of the raw material. The whole shaft, therefore, is perfectly free to move in gyratory fashion, as well as in a rotary and a vertical direction. At the bottom the gyratory drive is given by means of a short foot bearing in which the shaft rests, whilst allowing free movement, the arrangement also being on the ball and socket principle.

This foot bearing is given an eccentric motion because it is fixed in the right position, off the centre, inside an outer high speed vertical steel driving ring or pulley at the bottom of the machine, driven efficiently and noiselessly, up to about 450 r.p.m., by a belt, electric motor or other convenient means, no gearing being used.

The shaft with the crushing cone therefore moves in the crushing throat or concave with a gyratory motion, continually altering the crushing space in a horizontal plane, every portion of the cone and the throat taking part in the action, one of the reasons for the efficient performance. Also the crushing space in a vertical plane gradually diminishes from top to bottom. The lumps of material are simply thrown in at the top and pass down all round in the eccentric crushing space, the resulting material being

discharged continuously from underneath by an inclined spout. To adjust the crushing space, that is the size of the final product, all that is necessary is to alter the position of the large adjusting nut, which moves the shaft with the crushing cone in a vertical direction relatively to the throat and increases or decreases the horizontal distance. If any uncrushable material, such as a piece of iron, should be present no harm is done, since the vertical shaft moves downwards momentarily against the compression of the springs and allows the material to pass through.

One of the most valuable features of the machine, especially for stone crushing in road work, is that the crushed material is always in the cubical form, quite different, for example, from many types of hammer mill in which for cubical crushing the manganese steel hammers have to be replaced every few weeks.



301	Spider cap.	316	Balls for bearing.	361	Bottom driving disc.
302	Spider.	317	Shield ring.	363	Driving dog.
304	Bolts for spider.	318	Main shaft.	364	Lock ring.
305	Key for adjusting nut	319	Lower shell.	366	Bolt for bottom driving disc.
306	Adjusting nut.	325	Discharge spout.	368	Gasket for bottom driving disc.
307	Spider bushing.	328	Lower dust cover.	371	Pin for key.
308	Suspension ring.	328A	Ring for lower dust cover.	372	Oil ring.
309	Spider wearing ring.	330	Filter tank.	378B	Bolt for eccentric.
310	Lock nut.	330A	Oil tank.	379	Upper ball race ring.
310A	Lock nut sleeve.	332	Wearing plates, R. & L.	380	Lower ball race ring.
310B	Clamp collar.	334A	Ball for eccentric.	381	Ball retainer ring.
310C	Pin for lock nut sleeve	336	Eccentric.	394	Packing for lower dust cover.
310D	Pin for clamp collar.	337	Bottom plate.	397	Bushing for bottom plate.
310E	Bolt for lock nut.	338	Bolt for bottom plate	399	Pump.
311-1	Mantle core.	342	Pin for ball.		
311-1	Mantle.	345	Pulley.		
312-1	Concaves.	359	Key for lock ring.		
313	Top shell.				
315	Upper dust cover.				

A sectional elevation of the "Kennedy" crusher showing the arrangement of the plant as developed for fine crushing.

The "Kennedy" crusher, as already stated, is made in a number of sizes in two modifications—that is, the standard machine and the "S" type for fine crushing. Mainly, this latter is intended for a secondary reduction or final crushing, taking smaller pieces of material.

The usual range available covers machines with receiving openings from 1¾ in. to 14 in. wide at the top and adjustable as required down to say ⅛ in. wide at the bottom, taking 2–200 h.p. As typical, for example, one of the smaller machines has a 4¼ in. receiving opening reduced to ⅛ in. if necessary, and requires approximately 15–25 h.p. Approximately also the machine weighs 12,000 lb. for the standard type and 13,000 lb. for the "S" type. A larger machine has a 14 in. receiving opening reduced as required down to ½ in., and takes 100–150 h.p. weighing 180,000 and 192,000 lb. respectively.

As regards the duty, taking dry limestone as a standard, the latter machine will crush 156 tons per hour down to ½ in. size, 224 tons down to ¾ in. size, and 400 tons down to 1½ in. size. For the small machine mentioned of 15–25 h.p. the figures are 18 tons per hour down to ½ in. and 22 tons per hour to ¾ in.

A.S.T.M. Proceedings, 1933.

THIS is published in two parts, Part I. containing the annual reports of 40 A.S.T.M. standing committees, and research and sectional committees. Seven extensive technical papers are included with reports. The report on cast iron gives the results of the extensive co-operative investigation on impact testing. This section contains what is probably one of the most comprehensive series of data on the physical properties of cast iron ever assembled in America. Also of much significance in this section are the extensive data on corrosion developed in the investigations on field tests of metallic coatings and total immersion tests; discussion of co-operative short-time high-temperature tension tests; and the determination and significance of proportional limit and breaking strength in short-time high-temperature tests. In that part dealing with non-ferrous metals there are reports on corrosion, with extensive data from the results of atmospheric corrosion tests of metals exposed for one year; electrical-heating and electrical-resistance alloys, copper and copper alloys, and die-cast metals and alloys.

In Part II. all of the formal technical papers presented at the 1933 annual meeting, with the extensive oral and written discussion, are included. For convenience, papers dealing with metals appear together, and the others on cement and concrete, ceramics, masonry materials, and miscellaneous are also grouped. Two of the technical contributions are outstanding—the lecture on "Crystalline Structure in Relation to Failure of Metals—Especially by Fatigue," and the symposium on cast iron. The former was delivered by Dr. H. J. Gough, and is based on his extensive research work of over ten years at the National Physical Laboratory. The cast iron symposium was jointly sponsored by the American Foundrymen's Association and A.S.T.M., and was prepared by a committee of outstanding authorities. It presents concise, authoritative data on the composition, metallurgy, and properties of the many grades of cast iron now available.

Several papers discuss the development and application of tests for specific properties of metals, including the torsion impact test, modified Rohn test for creep of metals, and an "overnight" test for determining endurance limit. Papers on the fatigue properties of light metals and alloys, corrosion resistance o. structural aluminium, and tests of galvanised wire under pulsating tensile stress make available very valuable information and data on these subjects. Other papers discuss the effect of lead additions on the hardness of tin-base bearing alloys at elevated temperatures, effect of sulphur and iron on physical properties of cast red brass, comparison of white-metal bearing alloys at elevated temperatures, and consistent data showing the influence of water velocity and time on the corrosion of iron.

A number of technical contributions on miscellaneous subjects are given, including the agglutinating value test for coal, method and apparatus for the recovery of asphalt, relative merits of film and paper for industrial X-ray work, factors in the presentation and comparison of particle size data, and planning for the collection of standardisation data.

Copies of Parts I. and II. can be obtained from A.S.T.M. Headquarters, 260, S. Broad Street, Philadelphia, at $5·50 per part in heavy paper binding; $6, cloth; $7, half-leather.

Institute of Metals

Annual General Meeting held in London.

THE twenty-sixth annual general meeting of the Institute of Metals, which was held in the Hall of the Institution of Mechanical Engineers on March 7 and 8, proved as successful as previous meetings. Considerable enthusiasm prevails amongst the members of this Institute, a desirable condition which is undoubtedly due to a progressive Council and an able staff, a fact which is readily deduced from the report. As is well known to readers, the period covered by this report was specially notable both for the celebration of the twenty-fifth anniversary of the Institute's formation and the setting up of improved methods of publishing the journal. Despite the difficulties encountered as a result of another year of industrial depression, which has caused a slight reduction in membership and financial resources, there can be no doubt that the usefulness of this Institute to its members is increasing.

At the commencement of the business meeting, held on the morning of March 7, the retiring President, Sir Henry Fowler, K.B.E., LL.D., D.Sc., inducted the new President, Dr. H. Moore, C.B.E., into the chair, who, in his address, made some observations on current policy and the present position of the Institute. Referring to criticism which is made from time to time regarding the type of papers published by the Institute, and which he considered a healthy sign, Dr. Moore stated that the Institute rarely asks for or directly inspires papers on a particular subject or of a particular type. There is one complaint, however, which is rather familiar—the paucity of "practical" papers. It is not generally appreciated that the metallurgist who carries out a piece of research always prepares a report or paper about it, and does his best to have it published, unless there is some important reason why he should not. The practical man, on the other hand, who has improved his particular line of manufacture beyond the average level, is often satisfied with the other well-deserved rewards of his ability and work, and has natural reluctance to publish the technique developed. Frequently he is much too busy to prepare papers: certainly it is not through lack of ability of expression. Dr. Moore gave figures to show that the field of study of the non-ferrous metals and their utilisation is large, important, and increasing. In this sphere the Institute has played a great part in the encouragement of science. It exists to promote the science and practice of non-ferrous metallurgy, but as practice becomes increasingly dependent upon science, he suggests that the Institute must always be primarily a scientific body. Continuing, Dr. Moore referred to some close contacts of ferrous and non-ferrous metallurgy, and suggested some scheme of co-ordinating the publication of extracts in metallurgy, now published separately by the Iron and Steel Institute and the Institute of Metals.

In the industries and institutions in which we are interested, said Dr. Moore, we must accustom ourselves to the idea of constant change, of continual progress, of the rapid absorption and application of new knowledge and fresh ideas. The alternative is growing disharmony in our technical and economic organisation as we fail to change in a changing world. In industry it is not merely a matter of losing markets to our competitors; this is a symptom, though a very important one, of a failure to take our part in the march of progress. In a reference to the interdependence of ferrous and non-ferrous metallurgy, Dr. Moore said it would at once be admitted that on the purely scientific side the distinction between the two sides was wholly artificial. He mentioned the common ground of study in relation to corrosion, although stating that in the casting of metals the connection was less obvious.

Dealing with the intensive investigation of the creep of materials under stress at high temperatures, he said, engineering and chemical progress continue to make more insistent demands for materials to withstand high temperatures. Much of this work is necessarily empirical, amounting to the determination of the creep characteristics of steels of different types and the study of the effects of different alloy elements on creep. Attention is being given, however, to the fundamental causes and mechanism of creep, which are probably much the same in the creep at atmospheric temperatures of metals and alloys of low melting point as in steels at high temperatures. The effects of crystal size, recrystallisation, etc., are more easily investigated at ordinary temperatures, and it seems probable that the study of creep in alloys of lead, tin and other metals of low melting point, a study practically important in itself in other connections, may also throw light on the mechanism of high-temperature creep in alloys of high melting point, including steels.

A number of technical sessions were held subsequently, at which papers were presented covering investigations on a wide range of subjects. It is only possible to refer to these somewhat briefly here.

MINIMUM DIMENSIONS OF TEST SAMPLES FOR BRINELL AND DIAMOND PYRAMID HARDNESS TESTS.

Experience has shown that the results obtained in Brinell and diamond hardness tests may be dependent, in limiting cases, on the size of test impressions relative to the dimensions of the particular samples of metal on which the tests are made. Tests on similar materials but of different size give impressions of different size. This behaviour is well known in actual practice, and certain minimum requirements for dimensions of test-pieces are indicated in the British Standard Specifications for Brinell and diamond pyramid hardness tests. These requirements, however, appear to be based on very limited test data, and experience of hardness testing at the National Physical Laboratory has shown that the standard requirements, whilst satisfactory in some cases, do not necessarily apply to all cases.

The investigation which is the subject of this paper by Dr. G. A. Hawkins and Mr. C. W. Aldous was carried out to determine the effect of variations in the dimensions of test samples on the results of Brinell and diamond pyramid hardness tests, and to enable minimum dimensions of test samples to be suggested. The work, which is of particular importance in regard to Brinell tests on bars and thin plates, and in regard to both Brinell and diamond pyramid hardness tests on metal sheet and strip materials, comprises an experimental examination of (*a*) effect of width of specimen on Brinell hardness test results; (*b*) effect of thickness of specimen on Brinell hardness test results; (*c*) effect of thickness of specimen on diamond pyramid hardness tests results. The metals investigated include copper, brass, aluminium, and steel.

As a result of the investigation, the authors concluded

that a width of test-specimen of four and a half times the diameter of the impression is satisfactory for accurate Brinell tests on all the materials examined. In regard to the thickness of samples for Brinell tests, the limiting value of the ratio of thickness of test sample to depth of impression for accurate results appears to be a characteristic of the test material; a value of the ratio of 6 is required for mild steel, about 15 for copper, and more than 20 for spring steel. In carrying out diamond pyramid hardness tests on thin samples, a limiting value of the ratio of test-sample thickness to impression diagonal of 1½ gives results which are practically independent of test-sample thickness for the majority of sheet metals, with the exception of soft copper and soft brass.

INFLUENCE OF GASES IN AN 8% COPPER-ALUMINIUM ALLOY ON NORMAL AND INVERSE SEGREGATION.

Several observers have noted that dissolved gases in alloy melts are liable to show inverse segregation on solidification. The significance of dissolved gases, and the manner in which they may affect the mechanism of solidification so that inverse segregation phenomena result, has been a matter of keen controversy and of much speculation. Many theories have been advanced, but practically no experimental work has been directed towards a correlation of the exact gas content of the melt and the nature of the segregation in the resulting ingots.

A few experiments which have been made with an 8% copper-aluminium alloy—3L11—are reported in a note by Dr. I. G. Slater, in which the relationship between gas content and segregation for this alloy has been determined. In a sand-cast ingot, 3 in. diameter by 3 in., segregation was found to be inverse with very gassy melts, but to be normal with degassed melts. The author makes no attempt to discuss the results of his experiments, since it is intended that they should indicate a profitable line of investigation.

THE DIFFUSION OF ZINC AND IRON AT TEMPERATURES BELOW THE MELTING POINT OF ZINC.

Some preliminary experiments carried out about eighteen years ago showed that when pieces of zinc and low-carbon steel with smooth surfaces were clamped together and heated to a temperature somewhat below the melting point of zinc for about 48 hours, the two metals became strongly adherent to one another. During the last twelve months Mr. Gilbert Rigg has studied the matter in considerable detail in order to elucidate this action, the object of the investigations which he describes in this paper being to study the diffusion of zinc and iron at such temperatures with special reference to the structure and composition of the product of diffusion.

It is shown that when clean-rolled zinc sheet is heated in close contact with clean iron diffusion commences at below 300° C., and is fairly rapid at above 380° C.; it proceeds by the formation of cones of diffusion products, which spread out from isolated points where the contact between the metals is most perfect, and gradually penetrate into the zinc and across its surface. The progress of the diffusion is governed to a large extent by the nature and smoothness of the iron surface, and does not seem to be dependent on the vapour pressure of the zinc. Two well-defined layers of diffusion products are formed, a thin layer of constant thickness (about 0·08 mm.) containing about 17% iron, being next to the iron, and a thicker layer containing 0·11% iron outside this. On continued heating, the thin layer moves towards the zinc, being continuously converted into the zinc-rich layer; this would seem to indicate that the principal diffusing constituent is the iron. The rate of penetration depends on time and temperature, and is independent of the grade of zinc, but the thickness of the zinc-rich layer is less with electrolytic than with pure zinc. The mechanism of the diffusion process is discussed.

A STUDY OF THE INFLUENCE OF THE INTER-CRYSTALLINE BOUNDARY ON FATIGUE CHARACTERISTICS.

The research in progress at the National Physical Laboratory on the fundamental aspects of fatigue failure has been conducted up to the present mainly by tests on specimens consisting of only one crystal. This method of attack was adopted because experience of the fatigue failure of crystalline aggregates had shown that failure normally commenced within one or more of the constituent grains, the cracks formed within the crystals being afterwards propagated across the intercrystalline boundaries into the adjacent grains. Tests on specimens consisting of a single crystal appeared, therefore, to afford opportunities for studying in a fundamental manner the primary formation of fatigue cracks under known conditions of stress and strain. Having determined these characteristics, the effect of the intercrystalline boundary could then be approached by a study of specimens containing various numbers of large crystals.

The first tests on single crystal specimens were made on specimens of aluminium, and the results of tests under a wide range of stress conditions soon rendered possible the formulation for this material of one general law of deformation and the development of a descriptive theory of the process of fatigue. Attention was next devoted to other materials, experiments being made to determine whether the same general law of deformation and the same process of fatigue were applicable to all metals. With this object, tests were carried out on single crystals of iron, zinc, antimony, silver, and bismuth.

This paper by Dr. H. J. Gough, Messrs. H. L. Cox and D. G. Sopwith, describes the results of tests under alternating torsional stresses on three specimens of aluminium, each consisting of two crystals. In one specimen the boundary between the constituent crystals was mainly transverse to the axis of torsion; in another the boundary was mainly longitudinal through that axis, whilst in the third the boundary was irregular, but the two constituent crystals were in mutual twin orientation. The orientation of the constituent crystals in each specimen was determined before test by X-ray analysis, and the processes of deformation and failure were studied in relation to the structure of the crystals and to the distribution of resolved stresses on the slip planes.

The deformation occurring during test has been studied by observation of the slip bands produced, and particular attention has been paid to the markings in the immediate neighbourhood of the intercrystalline boundaries. The distribution of slip bands showed that the effect of the boundaries on the distribution of stress was extremely slight, each crystal of each specimen behaving as if it alone composed the whole specimen; whilst the close approach of the general systems of slip to the boundary and the very small amount of anomalous slip in that region showed that even locally the boundary had a very limited field of influence. Although major differences of behaviour of the three specimens were not observed, the deformation of the specimen with the longitudinal boundary and of the twin specimen, in which the boundary was irregular, did appear to occur with rather less ease than in the case of the specimen with the transverse boundary; and although the present tests were not sufficient to establish definite differences of fatigue strength, they showed that the orientation of the boundary had a considerable effect at least on the endurance at any given range of stress. The presence of the boundaries appeared scarcely to affect the formation and propagation of cracks. In each specimen cracks were formed in a normal manner in regions of previous heavy slip, and in their development showed no tendency either to avoid the boundary or, on the other hand, to seek it out. In one or two cases, cracks commenced to propagate along the boundary, but proceeded thus for only a short distance before deviating entirely into one or other of the crystals.

It appears that the presence of intercrystalline boundaries may considerably strengthen the constituent crystals against fatigue, but that the effect of the boundaries on the distribution or even on the amount of slip is very small. It is probable that the major effect of the boundary may lie in some restriction of strain that it imposes. Further investigation of this aspect of the problem will be undertaken.

THE VISCOUS PROPERTIES OF EXTRUDED EUTECTIC ALLOYS OF LEAD-TIN AND BISMUTH-TIN.

It has been observed that when extruded rods of eutectic alloys, with low melting points, were loaded slowly in tension, or stressed continuously under a small load, they showed deformation, apparently of a viscous character, to an extent greatly in excess of their normal plastic behaviour under rapidly applied stress in either the cast or extruded condition. One alloy, the bismuth-tin eutectic, showed almost complete absence of ordinary plasticity, and pieces dropped on a hard floor broke easily in a brittle manner, yet extruded rods could be slowly elongated by several hundred per cent.

Experiments described in this paper by Mr. C. E. Pearson, on the eutectic alloys of lead-tin and bismuth-tin, when in the extruded condition, show that they can be deformed in a viscous manner. Elongations up to 2,000% have been obtained in tensile tests employing prolonged loading. By the use of an apparatus designed to maintain a constant stress on the test-piece during extension, it has been shown that deformation takes place at a uniform rate which is greatest in freshly extruded rods and decreases with age or on annealing. The viscosity possessed by the alloys is not that of simple liquids, but resembles that shown by some disperse systems in which the viscosity coefficient is a function of the stress causing flow. The locus of viscous flow is found to be at the intercrystalline boundaries. It is particularly pronounced in these extruded alloys owing to the persistence of a very small grain-size after recrystallisation. Measurements have been made which appear to relate the decrease in the viscous property on ageing or annealing with an increase in the grain size.

The viscous properties shown by solid metals do not lend themselves as a rule to comparison with the viscosity of other materials, although their behaviour in this respect is sometimes considered to resemble that of glass or pitch. In most cases where viscous effects are well marked, as, for example, in experiments on creep, it is difficult to dissociate the purely viscous flow from deformation occurring in other ways. It is not the intention of the author to attempt any general discussion of the phenomenon of viscosity, but in view of the magnitude of the viscous deformation shown by the alloys and the apparent absence of masking effects, he puts forward a few relevant considerations.

VISCOUS AND PLASTIC FLOW IN SOFT METALS.

This note by Dr. Ing. E. W. Fell deals with a certain type of flow observed in soft metals, eutectics included. In particular, the flow of the metal in a prolonged ball-hardness test is compared with the flow in tensile test-pieces under a constant stress per unit area of cross-section.

A formula concerning the continuous penetration into the metal of a ball under a constant applied load is discussed, with particular reference to the constants in the formula. A result is given of the assumption that the change in the diameter of the ball-impression with time is a function of the flow of the metal. A formula concerning the increase in length with time of tensile test-pieces under constant stress is discussed regarding constants. The applicability of the ball and tensile methods is considered, and constants compared. One formula relates to the change in rate of extension with stress, and a comparison is made with viscosity.

CASTABILITY OF TERNARY ALLOYS.

The ultimate aim of every foundry operation is to obtain a complete and perfect filling of the mould with the liquid metal, so that, after cooling, the casting exactly resembles the pattern and is of the required dimensions within the limits of error imposed by the nature of the metal. The realisation of such a result implies the knowledge of the two fundamental properties of metal founding—*castability* and *shrinkage*,—and this investigation, by Professor A. Portevin and Dr. P. Bastien, which is reported in this paper, defines the term castability and the laws which control the castability of pure metals and binary alloys. The interesting results obtained with binary alloys incited the authors to study the variation of the castability of ternary alloys, and especially to determine the effect of successive crystallisation intervals and their relative importance.

The ability of a molten metal or alloy to fill a mould completely is termed " castability " ; it can be determined by ascertaining the length of a spiral cast-iron mould filled by the metal under predetermined casting conditions. As a result of tests, it is shown that the castability of a pure metal is a linear function of the difference between the pouring temperature θ and the melting point F; the slopes of the castability ($\theta - F$) curves vary with the viscosity of the metal. The castability of binary alloys varies with the solidification range and with the mode of crystallisation, being greater when polyhedral crystals separate than when the primary crystals are dendritic. Maximum castability occurs with the eutectic composition and minimum at the limit of solid solubility.

The castability of ternary alloys varies inversely with the primary solidification range, and, in cases where this is nil—*i.e.*, along the binary eutectic lines in the ternary system,—it varies with the secondary solidification range, reaching a minimum at compositions corresponding with the transition from two-phase to three-phase fields. These laws are illustrated with reference to several binary antimony alloys and to ternary alloys of lead, tin, and bismuth, and of iron, carbon, and phosphorus. Finally, the authors discuss the value of this method of testing alloys for practical foundry work, and it is shown to be useful in determining the composition of eutectics and of saturated solid solutions in metal systems.

ALLOYS OF SILVER AND BERYLLIUM.

The investigation reported in this paper by Mr. H. A. Sloman is part of the work on beryllium and its alloys which has been carried out for the Minor Metals Committee of the Metallurgical Research Board, Department of

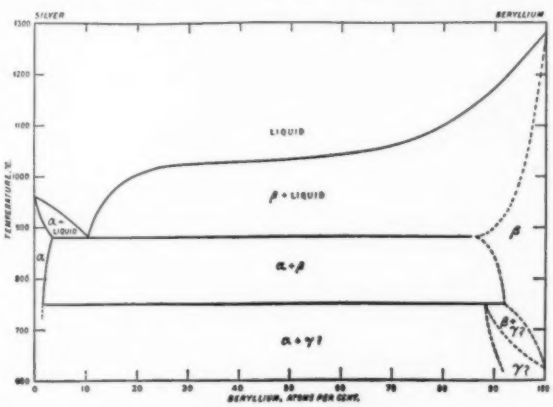


Fig. 1.—Proposed constitutional diagram for silver-beryllium system.

Scientific and Industrial Research. The investigation was to include the addition of beryllium to high- and low-grade silver alloys, particularly those containing copper. In the case of low-grade silver alloys containing copper, no

advantages were found by the introduction of beryllium, but it was observed that within certain ranges of composition separation into two liquid layers occurred. This immiscibility disappeared on the addition of nickel. The results of the work are discussed in Part I., while those on high-grade alloys are given in Part II.

The constitution of the whole range of alloys in the silver-beryllium system has been redetermined by thermal and micrographic analyses, and the results are given. The proposed constitutional diagram is shown in Fig. 1, which modifies and amplifies the original constitutional diagram by Oesterheld.

In this investigation a series of alloys ranging in composition from 90 to 100% silver, 0 to 1·2% beryllium, and 0 to 10% copper was subjected to a tarnishing test. Examination of the results revealed that two opposing factors were in operation. Increase in the beryllium content led to more complete immunity, whilst decreasing the silver or, rather, increasing the copper, led to less complete protection. In all cases the maximum immunity was obtained when the beryllium content had reached about 0·4% by weight. Further additions of beryllium seemed to have very little effect. It is to be noted that the solid solubility of beryllium in alloys of this type is approximately 0·4% by weight, and it appears that once the alloy is saturated with beryllium in the form of a solid solution—that is to say, once the beryllium is uniformly and finely dispersed throughout the whole mass—any excess, present either in the eutectic ground mass or as a primary constituent, has no further influence on the tarnish-resisting properties of the alloy.

TRANSVERSE TESTS OF SAND-CAST ALUMINIUM ALLOY BARS.

Many of the aluminium alloys at present employed in industry possess, particularly in the sand-cast state, so little ductility that measurements of elongation made on broken tensile test-pieces are of but small value. It has been suggested that a bend test such as is already employed in the testing of cast iron might prove to be of greater value, and the investigation described in this paper by Messrs. C. E. Phillips and J. D. Grogan was carried out to examine this point.

So far as this investigation extends, the bend test applied to sand-cast aluminium alloy bars has yielded no information concerning ductility which is not obtained from the tensile test. On the test-pieces employed in this investigation the ratio of plastic deformation to total deformation of a test-piece loaded to the breaking point is higher in the tensile test than in the bend test, particularly when the plastic deformation is small. Consequently the tensile test is preferable to the bend test for the measurement of ductility.

Bend tests on machined and unmachined bars have given very satisfactory agreement, while measurements of elongation on broken tensile test-pieces have given values higher than those obtained from complete load-extension curves.

THE CONSTITUTION OF COPPER-IRON-SILICON ALLOYS.

Copper-rich alloys containing metallic silicides have attracted attention recently on account of their capacity for heat-treatment, but very little has been published on the subject of the constitution of these alloys. This paper, by Professor D. Hanson and Dr. E. G. West, deals with alloys of the system copper-iron-silicon, in which the constitutions of alloys containing up to 8% of iron and 8% of silicon have been examined. It is shown that the solubility of iron in copper is decreased by the presence of silicon. Over the greater portion of the range of compositions examined, iron exists in the alloys as such, containing only a small amount of silicon and copper in solution; its solubility in the solid state decreases rapidly with fall of temperature and becomes very small below 700° C. Within certain ranges of composition, iron and silicon combine to form another constituent, probably FeSi, which forms a series of alloys with the α solid solution. FeSi also appears to form systems of alloys with the α, β, γ, δ, and ϵ constituents of the copper-silicon series. The shape of the liquidus and solidus curves has been determined, and the changes occurring in the system during the process of cooling from the liquid state have been indicated.

The constitution of the alloys suggests the possibility of modifying their mechanical properties by heat-treatment.

TRANSFORMATIONS IN THE COPPER-PALLADIUM ALLOYS.

Copper-palladium alloys up to 55 atomic per cent. of palladium have been examined by thermal, micrographic, and electrical resistance methods, the results of which are given in this paper by Mr. R. Taylor. In the range 10–30% of palladium, the electrical resistance-temperature curves for the transformation from an irregular to a regular distribution of the atoms on the points of a face-centred cubic lattice are explained on the assumption that a lattice distortion, which produces a small increase in resistance, is followed by the ordering of the atoms which causes a large diminution in resistance. The highest temperature for the commencement of the first stage is about 570° C. at a composition near 22% of palladium. The corresponding figures for the second stage are 500° C. and 15%. The minimum specific resistance in the ordered state is $8{\cdot}1 \times 10^{-6}$ ohm-cm. at 20° C. in the 15% palladium alloy. The increase due to the transformation is greatest at 25% palladium.

In the range 35–55% palladium, the transformation from a face-centred cubic lattice with the atoms arranged irregularly to a body-centred cubic lattice with an ordered distribution of the atoms takes place completely near 40%, but only partly on cooling in alloys near the limiting compositions. The change in the latter case can be made more complete by quenching from 600° C., cold-rolling, and then annealing at 450° C.

In no case has the transformation been found to take place at constant temperature, the range being smallest and the temperature highest at 40% palladium. The specific resistance in the ordered state is a minimum at 47% of palladium ($3{\cdot}1 \times 10^{-6}$ ohm-cm. at 20° C.). There are two breaks in the specific resistance-composition curve for the irregular arrangement of the atoms, at 32·5 and 42% palladium, respectively.

THE MALLEABILITY OF NICKEL AND OF MONEL METAL.

In this paper, by Mr. Owen W. Ellis, a brief review of the literature on the subject is followed by a discussion of the effect of annealing temperature on the hardness of two rods—$\frac{1}{2}$ in. and 1 in. in diameter, respectively—of cold-drawn nickel, which were the subject of malleability tests at temperatures varying from 250° to 1,100° C. The relationship between energy of blow and percentage reduction in height of normal $\frac{1}{2}$ in. samples is demonstrated, as is the influence of the initial hardness of the same material on its resistance to deformation at 750° C. The paper concludes with a description of experiments: (1) On the effect of annealing normal samples of the 1-in. material on its malleability at 800°, 900°, and 1,000° C.; and (2) on the malleability of Monel metal.

THE CONSTITUTION OF THE MAGNESIUM-RICH ALLOYS OF MAGNESIUM AND NICKEL.

This paper, by Messrs. John L. Haughton and J. M. Payne, is a report of the first part of a comprehensive study on the alloys of magnesium at the National Physical Laboratory. In this investigation the constitution of magnesium alloys containing up to 50% nickel has been studied by thermal and microscopic methods. It is shown that magnesium forms a eutectic with the compound Mg_2Ni at a temperature of 507° C., and a composition of 23·5% nickel. The solubility of nickel in solid magnesium is less than 0·1%.

Automatic Reversal of Open-hearth Furnaces

A reversal system which operates automatically on a temperature-difference principle is discussed, which is claimed to effect considerable saving in the operation of the open-hearth furnace. Comparative figures from a large steel plant are given.

IT is well known that the successful and economical operation of the open-hearth furnace depends largely upon adequate control. This not only affects regulating the quantity of air and gas, or the chimney draught, but also the operation of the change-over valves. These valves are recognised as an important part of the whole regenerator system, as the time of reversal must be accurately determined and consistently maintained in order to obtain the highest efficiency from the regenerators. For many years the reversal of open-hearth furnaces has been based upon an empirical time-cycle, but in some recent installations the Integra Co., Ltd., have fitted a more efficient system, which operates on a temperature-difference principle.

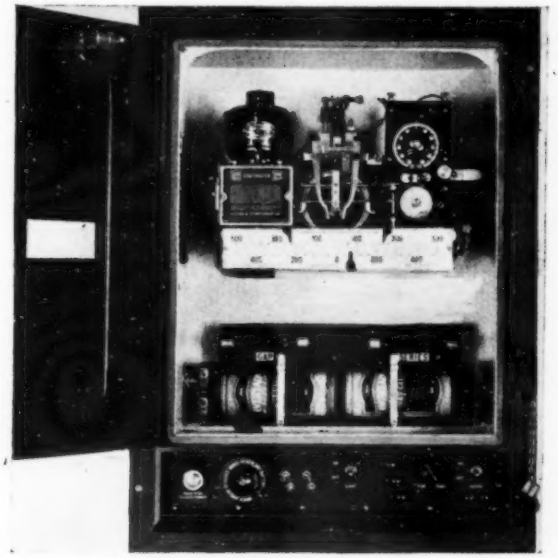


Fig. 1—Reversal controller with case opened.

The weakness of the manual reversal is the uncertainty of the operator's response to the demands of the furnace. Even when the operator has pyrometric guidance, he will rarely reverse the furnace at the proper instant; whereas, with this automatic reversal method, the furnace itself may be said to decide when it should be reversed. Heat conditions in any open-hearth furnace change rapidly, and as the checker system on the side which is heating approaches a certain temperature—its so-called point of saturation—the heat absorption decreases at a rapid rate. This means, of course, that as this point is neared, increasing quantities of heat go out of the stack. Thus, there is one correct point for reversal, a point which is variable, not only with each furnace, but also with each reversal, during any one heat throughout the campaign of the furnace. To delay reversals beyond this point would cause a waste of heat which could and should have been turned back into the furnace. In modern open-hearth practice the correct point for each reversal is established in practical operation by means of the automatic temperature difference reversal controller.

It is noteworthy that this system was developed as a result of a thorough investigation by the engineers of Leeds Northrup Co., the principal object of which was to establish a reversal control based upon the actual conditions occurring during operation of the furnace, in order to return to the furnace a greater amount of heat: to establish and maintain a balanced thermal condition between the two sides of the furnace; to provide absolute freedom for the operator in developing or building up the heat head during the progress of each heat; and to provide a safeguard against early burning-out of the regenerative chambers. Many different methods of reversal—both from temperature and from time, some automatic, some semi-automatic, and some entirely manual—were tested in actual operation. Heat absorption, heat loss, thermocouple location, valve operation, fuels, etc., in fact, all the known factors affecting operation, were carefully investigated and tabulated under varying conditions, and the automatic temperature-difference method proved to be superior for open-hearth furnaces.

This automatic reversal equipment consists of a controller and a two-point recorder for showing air-flue or checker chamber temperatures. Two thermocouples are installed in the flues near to the checker chambers, while couples for the potentiometer recorder are located adjacent to the control couples in the same protecting tubes. The controller is mounted on a panel with the recorder, and is located on the charging floor, opposite to each furnace. When the temperature of one thermocouple exceeds the temperature of the other by a predetermined number of degrees, the controller reverses the furnace, and, it is important to note, the reversing sequences are co-ordinated and interlocked so that the reversal is completed in a definite and minimum time, that once established, each reversal will occupy the same number of seconds. The scale on the controller is calibrated to show the total difference setting on each side of a zero point, and the contact points are readily adjusted along the scale to the

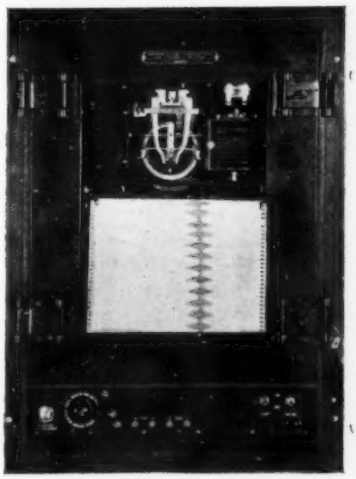


Fig. 2.—Two-point potentiometer installed in vapour-proof cabinet for flush mounting on panel.

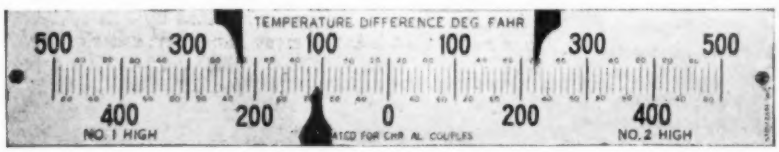


Fig. 3.—Controller scale set with a temperature - difference of 220°F.

temperature difference at which the control is set. Thus, reversal is made as frequently as desired without disturbing the heat balance, simply by narrowing the temperature-difference limits set on the controller.

The reversal controller and the temperature recorder operate on the potentiometer principle, and all parts are standard equipment, as also is the automatic reference junction compensation. The reversal controller, shown in Fig. 1, is equipped with either of two ranges: ± 1,000° F. when the control thermocouples are located in the air flues, just outside the regenerator chamber; and ± 500° F. when the couples are located in the checker chambers. When the thermocouples are set in the checker chambers, the scale on the reversal controller is similar to that shown in Fig. 2, which, it will be noted, is set with temperature-difference limits of 220° F. The moving index at the bottom

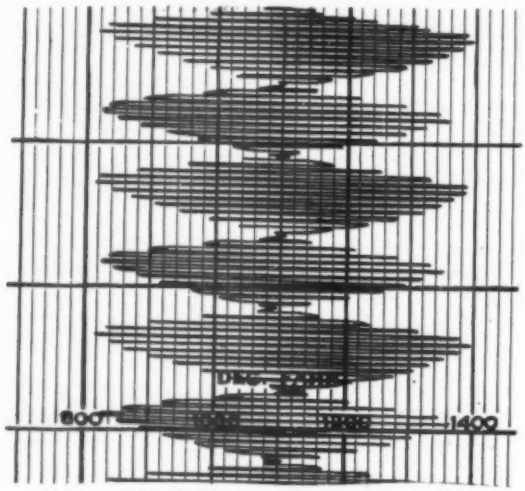


Fig. 4.—Showing part record of cycle of preheat.

of this scale shows the actual temperature difference. The temperature difference desired before reversal is set by rotating a knob on the panel which moves to contact points into the desired relation to two discs. At the same time, the indices are moved along the calibrated scale to show the temperature difference at which the control is set. When the furnace is sealed over the week-end, and the two control locations cool down at an equal rate so that no temperature difference exists, by throwing a switch from temperature to time position, a time contactor will reverse the furnace at constant time intervals. The switch is again operated when the furnace is restarted, to reverse by the temperature-difference method.

The two-point recorder shown in Fig. 3 is used to record air-flue or checker-chamber temperatures. It draws a clear, easy-to-read record, as is indicated in the part temperature curves shown in Fig. 4 of the temperatures of both ends of the regenerative system, furnishing an accurate record of the cycle of preheat. Both the recorder and controller are mounted in the same type of vapour-proof cabinet, while the motor switch and circuit balancing rheostat also are mounted in a special compartment.

Some idea of the effect of this control on the efficiency of open-hearth furnaces may be obtained from the following comparative figures which relate to operations of open-hearth furnaces in a large steel plant over a consecutive period :—

	Four Furnaces under Automatic Control.		Six Furnaces under Hand Control.
Number of heats	141	..	212
Tonnage produced	12,232	..	17,812
Tons per heat	86·75	..	84·02
Total melting time	1,362 hours 40 mins.	..	2,236 hours 55 mins.
Average time per heat	9 hours 40 mins.	..	10 hours 33 mins.
Tons produced per operating hour	8·9	..	7·9
Fuel consumption per ton	5,323,200 B.th.u.	..	6,352,100 B.th.u.

It is claimed that the more regular operation resulting from this automatic control not only increases production in relation to fuel costs, but reduces refractory costs and raises the overall efficiency of the furnaces because of the maintenance of a correct heat balance.

STRAITS TIN.

In a handbook of information compiled for the purpose of making known the stages of development of Singapore from its foundation, and the administrative, commercial, industrial and social conditions at the present time, some information is given regarding tin smelting, from which the following is extracted.

THE tin ore deposits of the world are widely distributed, but the two areas of chief importance are the areas embracing the deposits of Malaya, Dutch East Indies, Siam, Burma and China; and Bolivia. Tin ore is also found in Australia, South Africa, and Nigeria, but not in very large quantities.

The British Empire supplies over 50% of the world's tin ore requirements, while the chief centres of the smelting and refining of tin are in the Straits Settlements and the United Kingdom. The Straits Trading Co., Ltd., Singapore, founded in 1887, carry on the business of tin ore smelters and general merchants. Originally the ore was reduced by a small reverberatory furnace in a shed at Teluk Anson, Perak, but the results were very disappointing. Shortly afterwards, however, the company erected smelting works at Pulau Brani, Singapore, and they exist there at the present time, though changed out of all recognition from their original layout and in regard to type of plant installed. The company possesses a second smelting plant at Butterworth, Province Wellesley, which was originally started in 1902 to keep pace with increasing business. This plant was completely modernised a few years ago.

The primitive Chinese methods of tin ore-smelting in small shaft furnaces, with charcoal as fuel and reducing agent, were replaced by smelting in small reverberatory furnaces. The latter, in their turn, gave way to large modern regenerative reverberatory furnaces, gas-fired, with modern fume recovery attachments. This progress in smelting practice has resulted in larger recoveries of metal from the ore, with benefit alike to the tin mining industry and the prosperity of Malaya in general.

The properties of the Straits Trading Co., Ltd., cover an area of over 70 acres, and the combined smelting plants at Pulau Brani and Penang are the largest and most up-to-date in the world. They have a total smelting capacity up to 80,000 tons of refined tin per annum. The product of these smelteries is the world-renowned "Straits Tin," the ore supplies coming mainly from the Federated Malay States. The total exports of tin and tin in ore from the Federated Malay States for the years 1929 to 1931 inclusive were :— Year 1931 : Tin, 5,855 piculs; tin in tin ore, 855,152 piculs; total exports, 861,007 piculs; total exports, 51,250 tons. (A Straits picul equals 133⅓ lb., or 16.80 piculs equal 1 ton.)

The introduction of modern methods of tin smelting has gradually resulted in the bulk of the ore being exported to the European smelters at Singapore and Penang for conversion into refined tin. The preponderating part of the output of tin ore from Malaya is smelted by this company, with the result that it is the most important seller of Straits refined tin in the East. Its head office is at Singapore, and it possesses buying agencies throughout the whole of Malaya, at which points the ore is received from producers for transport to the company's smelting plants. The technical and commercial organisations of the company are of a high order, and improvements in existing smelting methods and processes by metallurgical research are constantly aimed at.

The uses of tin are so well known as to require no comment here. "Straits Tin" is world renowned, and finds consumers in all parts of the globe, the biggest demand coming from the United States of America. It analyses over 99·85% purity, and possesses the physical characteristics so much desired by consumers; its softness is unexcelled, and it is uniform in quality. It is shipped in ingots weighing 100 lb., and each ingot is branded with the company's name.

A Projected British Foundry School

By J. G. Pearce, M.Sc., F.Inst.P., M.I.E.E.

(*Director, British Cast Iron Research Association*).

A new scheme is described which is fundamentally different from any other scheme of training. It is intended for men who are engaged in the industry and depend upon it for their livelihood. The author discusses other training schemes in operation which have led to the present development.

UNTIL a few years ago foundry education and training in Great Britain was in an unsatisfactory condition.* Classes in foundry work were held at a number of technical schools and colleges throughout the country, but difficulty was experienced in securing the attendance of those actually engaged in foundries, and the classes were in the main used by students of engineering who wished to obtain some general knowledge of foundry processes. However useful such provision may be for conveying the elements of practical training to those outside the industry, it is now generally acknowledged that it is difficult, if not impossible, for a technical school adequately to teach the art and practice of founding. The time available is too limited, the equipment is too scanty and often obsolete, and difficulty is often experienced in securing the services of the right type of instructor. Furthermore, the industry is changing very rapidly, and it is virtually impossible for a technical school to keep pace with these changes. The only place, in fact, where adequate practical training can be acquired is the foundry itself. With respect to the science of founding, which has grown enormously in recent years, the technical schools can and do carry out excellent work, and it is fully recognised that they undertake best the teaching of principles underlying the practice of the art.

The metallurgical degree courses at the universities normally cover the whole field of metallurgical practice and the time actually devoted to founding is small. This could, with advantage, be greatly increased, not only in metallurgical courses but in degree courses for students of engineering, architecture, building, and mining, as it is important that students who aspire to responsible positions in industry should be able intelligently to test, specify, inspect, purchase, and use cast products.

Some years ago systematic steps were taken by various representative bodies in the industry, notably the Institute of British Foundrymen and the British Cast Iron Research Association, to build up a national scheme of foundry education. A national scheme seeks to make specific provision for those actually in the industry, who, of course, have first claim on its consideration, and to arrange that the same standard of instruction shall be available irrespective of the accidents of local circumstances. It aims at providing nationally recognised as distinct from local certificates. The first consideration was the operative, the moulder, coremaker, and patternmaker. Arrangements were made, in conjunction with the City and Guilds of London Institute, for examinations in patternmaking and in foundry science and practice. Two examinations are now held yearly in patternmaking, intermediate and advanced, and one in foundry practice and science. The courses and syllabuses are supervised by an Advisory Committee nominated largely by the industry.

The next step was the institution of a national certificate, in conjunction with the Institution of Mechanical Engineers, for what might broadly be described as the technical grades in the industry: foremen, charge hands, estimators, inspectors, testers, chemists, metallurgists, and the ambitious operative who seeks higher responsibilities, or who wishes to learn more about the basis of his craft.

It has been recognised from the beginning that these foundations needed to be completed by a superstructure in the form of a course offering instruction of the very highest order for those who have marked themselves out for the highest posts and greatest responsibilities the industry has to offer, as foundry managers, chemists, metallurgists, and engineers. Such a scheme was foreshadowed by the author in lectures at Oxford in 1929 and Loughborough in 1931, and a scheme was framed in November, 1932, and in that month a discussion on its possibility was opened with the Board of Education. As the British Cast Iron Research Association is the only body of its kind in the country exclusively devoted to founding, and as the industry is predominantly concerned with cast and malleable iron, it is natural that the Association should provide the initial impetus for such a scheme.

It is necessary to emphasise that the school, proposals for the establishment of which are now outlined, will be completely independent, financially and otherwise, of the British Cast Iron Research Association, and while it is hoped that the contact between them will be of the most friendly description, the new school will have its own governing body, the Association taking its place as one of the constituting bodies concerned.

Reference should also be made to the proposals for the establishment at the University of Sheffield of a degree course in founding, made in March, 1933, through Professor J. H. Andrew.† The University then announced its willingness to provide degree and associateship courses for students of metallurgy desiring to specialise in founding, subject to the industry furnishing the necessary funds. The University requires the sum of £1,500 per annum, guaranteed for a period of seven years. The relationship of this course with the Association's proposals has naturally been the subject of careful consideration. It has been found that the two proposals do not in any way overlap; they are essentially different in aim, and this is fully recognised by the sponsors of the two schemes. The University course is intended for young men who would normally expect to take a degree course, but who have not yet entered the industry, and who believe that a specialised founding degree would be of assistance to them. The Association's proposals are intended solely for those actually engaged in the industry and who are already committed to it. As will be indicated below, the industry is for this scheme only required to furnish the sum of £500 per annum, and as the course lasts for one year, no lengthy period of guarantee is required; neither is any large outlay required for capital expenditure on equipment, for reasons which will be outlined below. The Board of Education has considered the two schemes, and has expressed the view that they fit into and supplement one another. The author represents the British Cast Iron Research Association on the Committee which is promoting the Sheffield scheme, and the Institute of British Foundrymen, and in particular the Committee sponsoring the Sheffield scheme, will doubtless be represented on the governing body of the school proposed by the Association. The Sheffield Committee has already expressed its approval and sympathetic support of the new scheme.

No technical college is in a position to offer training of the highest type in a full-time course, and, indeed, the prospective demand does not require the establishment of more than one such school for the whole country. The detailed proposals for such a school, to be governed by the

* Mr. A. Abbott's "Education for Industry and Commerce in England" is an admirable survey of the development of technical education. (Oxford University Press, 1933).

† See the "Foundry Trade Journal" March 16, April 13, November 23, 1933, and February 22, 1934. See also V. C. Faulkner, "Foundry Trade Journal," October 6, 1932.

industry itself but in full co-operation with the existing educational machine, can now be considered. They are, of course, subject to any modifications which the governing body may see fit to make.

The New School.

Its Status.—The school will form a new body, entirely independent of existing representative bodies in the industry and of the universities and local education authorities. In this respect it will be unlike any other school for industrial training in the country. It will be governed by a committee nominated by the representative bodies in the industry (trade associations, technical and scientific societies and research associations) and others who offer the necessary financial support. It will grant to successful students a national and State-recognised diploma, and no other school will be established to grant a similar diploma, which will thus have a national and nationally recognised value. The course will be a full-time course of one year's duration.

The school will not attempt to afford practical training, which can only be acquired in the foundry, and suitable practical knowledge will be a condition of admission, which will be confined to those actually engaged in the industry. The school will aim at furnishing men who have already gained this practical experience, who have some technical knowledge through part-time or full-time study, and who show promise and ability to undertake responsible work, with the most advanced information and knowledge in the science and art of founding that the country can offer. It will appeal to the foundry manager, the foundry engineer, the foundry chemist, and the foundry metallurgist, to men who aspire to these posts, and to men in all other posts for which the type of training is a recommendation. It is intended that the course shall cover the founding of grey iron, white iron, malleable cast iron, steel and non-ferrous metals, and that it shall appeal equally to large and small foundries, light and heavy foundries, attached and independent foundries, jobbing and specialised foundries, as all these types are likely to remain part of the permanent industrial structure of this country.

Location.—It is proposed to establish the school in Birmingham, which is geographically, industrially, and educationally very suitable. The city is easily reached from all parts of the United Kingdom and is centrally situated. It is the centre of the most densely populated foundry area in the country, an area which includes blast-furnaces, iron foundries of all types, for cast and malleable cast iron, non-ferrous foundries of all types, and steel foundries. The foundries of the area are modern in character, and the area has been advantaged by the so-called southern drift. The city possesses a civic university of the highest rank, which has the largest Department of Metallurgy of any university in the country, now in charge of Professor D. Hanson, who is well known for his work on cast iron. It also has a large and centrally situated Technical College capable of providing instruction up to university degree standard. While, of course, final arrangements will depend upon the acceptance of the scheme by the industry, it is anticipated that no difficulty will be experienced in arranging for the new school to be housed in the Central Technical College.

Admission.—The admission of students will be determined by the governing body, but it is probable that a start would be made with not less than ten students, and the maximum in attendance would probably not be allowed to exceed thirty. There will be no age limit for admission. It is anticipated that students will be required to pay a fee of about £30 for the course, which would last for a year. The cost of operation is estimated to be £2,300 per annum for the minimum number of students, increasing to £3,000 for the maximum. It will be evident that from sources other than fees, a sum of £2,000 per annum has to be furnished. In this connection the Board of Education has expressed its interest in the scheme, and, subject to the industry furnishing the comparatively small sum of £500 per annum and to the required number of students coming forward, is prepared to consider furnishing the remaining £1,500 per annum in the form of a direct grant. The funds of the school will be administered entirely by the governing body.

Since the school will not undertake practical training, it will be necessary that all prospective students should have had experience in a foundry, and a minimum of twelve months' practical experience will probably be required. Some students may take the course entirely on their own responsibility, but it is hoped that large firms will be willing to release promising members of their foundry staffs to attend the course and that the nominees of proprietors of small foundries will also attend. If sufficient students are forthcoming, the course will begin in October, 1934, or October, 1935. Prospective students are invited to communicate with the author, and, for the first year's course, preferably before the end of April, 1934.

A Serviceable Crank Axle.

Over 50 years ago, one of the many hundreds of locomotive crank-axles manufactured at the River Don Works—now Vickers Works of the English Steel Corporation—was despatched to Australia, and, in November 1881, was put into service by the New South Wales Government Railways on one of their engines. Since that date the locomotive in which this crank-axle was fitted has been continually in service, and altogether has run 917,400 miles, and, in the words of the Chief Mechanical Engineer, "the crank-axle was only removed owing to its locomotive being withdrawn from traffic—both the journals being in good condition and parallel."

It is interesting to think for a moment of the number of revolutions completed by this crank-axle during its long journey of 917,400 miles—approximately 300 millions. It will be realised that this is approximately three times the number of reversals of stress generally applied when carrying out longest duration fatigue tests. We understand the English Steel Corporation recently received another one of its crank-axles from the L. and N. E. Railway which had run 845,984 miles during its life of 40 years; another crank-axle on the L.M. and S. Railway completed over a million miles.

The pride and work of the craftsmen of 50 years ago still exists in the shops and is largely responsible for the excellent work produced, but it has the advantage in these days of the research work carried out in the extensive Metallurgical and Research Department of this Firm.

We understand that Messrs. W. H. A. Robertson and Co., Ltd., Bedford, have been appointed agents for the sale in the British Isles of the wrapping machines for wire, strip, hose and tyres, manufactured by the Terkelsen Machine Co., Boston, U.S.A.

Catalogues and Other Publications.

National Alloys, Ltd., 95, Gresham Street, London, E.C. 2' has just issued a brochure dealing with Mazak high-purity die-casting alloys. These are zinc base alloys, the No. 1 alloy consisting of 4% aluminium, 3% copper, 0.1% magnesium, and the remainder high-grade zinc, being well known. No. 2 alloy, recently introduced, is a greatly improved alloy of the Mazak group, and although the changes in composition are not radical, the resulting changes in properties are very significant, and increase its field of application.

High-production slotters having 14 in., 20 in., and 28 in. stroke are described in a new catalogue, No. 4A, just issued by the Butler Machine Tool Co., Ltd., Victoria Ironworks, Halifax. It includes illustrations of representative machines from standard belt-driven models to the larger sizes with electrically operated feed unit and pendant push-button control.

Sand, Clays and Minerals for February contains much valuable information. Amongst the many articles published in this issue, mention should be made of the "Analysis of Zircon Sand," "Tungsten and Its Uses," "Refractory Cements," "Manganese Dioxide for Colouring Bricks," etc., which will be found most interesting. It is published by A. L. Curtis, P.O. Box 61, Chatteris, England.

Present-day Gold Refining

(SPECIALLY CONTRIBUTED.)

Improved methods of the chemical system of separation are employed to some extent in this country, and in this article the author discusses this process as well as electrolytic methods.

IN the ordinary way it is generally considered that gold is largely refined by electrolytic methods, and that the chemical system of separation has nowadays largely fallen into disuse.

So far as the methods in this country are concerned, this is not entirely accurate, and although the former is widely practised in Germany, America, and elsewhere, improved applications of the latter are employed to some extent here to-day. The recent gold "rush" afforded ample opportunity for developments of all known processes for extracting and refining gold. Unlike most other metals of less monetary value, gold does not enjoy that wide research work or industrial progress as a result of so few firms working with it to any appreciable extent. A review of most of the systems of refining gold will readily reveal that those engaged on this work are slow to appreciate modern developments, and prefer to adhere to antiquated, although well-established, methods. An essential feature of gold refining is the rapidity with which all operations are carried out, as otherwise a small loss is liable to be sustained, due to bank interest.

The Wohlwill electrolytic process was first introduced in Hamburg in order rapidly to recover the gold in pure condition, whilst small quantities of the platinum metals associated were recovered in the form of anode slimes. The crude gold is cast into anode slabs, and in order to consume them rapidly, a high current density is necessary. So much anode slime formed on the surface of the slabs that the latter required to be frequently scraped throughout the electrolysis. This gave rise to the improved Wohlwill process used to-day, wherein an unsymmetrical alternating current is superposed on the direct current, whereby this difficulty is overcome.

The alternating current opposes the passivation, and further permits of much greater direct current being applied, although it does not do any actual deposition of gold by itself. This means that rapidity of working, which is so important in gold refining, is thus obtained.

In this country, gold does not appear to be refined by such highly scientific methods. This is largely due to lack of confidence in modern electrolytic applications, and failing to appreciate the principles of introducing the superposed alternating current.

More time has been devoted here to improving the earlier direct method of chemical separation.

Treatment of the Crude Gold.

The crude gold to be refined comes from a wide variety of sources. In the earlier stages of the extraction it is either recovered in combination with lead by smelting in reverberatory or blast-furnaces, or by wet chemical methods. In either case the rich material is placed on a "test" or cupellation furnace, and the base metal impurities removed in the form of crude litharge.

Greater latitudes have been permitted in the working of the "test" of recent years, and the rich lead containing appreciable amounts of base metal impurities is directly "cupelled." This is successfully carried out by maintaining a frequent addition of pure lead plates to the rich lead as it is being oxidised, and also using an improved hearth in place of that of ordinary bone-ash. Where the gold has been recovered by wet chemical methods, the rich residue is thrown on to the molten lead and readily becomes incorporated, after which the base metal impurities are oxidised out as before.

When it is known that much gold has accumulated in one lot of material, it is customary to work it on a "test" reserved for this purpose, as the rich silver lots may be refined at a lower temperature.

There is almost invariably a sufficiency of silver present to justify the rich metal being electrolysed for its recovery, and when the metal in the "test" has reached the final stages, it is cast into anode moulds by means of ladles. Silver electrolysis is nowadays almost entirely confined to the methods of "Moebius" or "Balbach Thum," which have been widely detailed elsewhere. The products from this electrolysis are pure silver deposit containing 99·98% silver, and rich gold slimes from the anodes, containing upwards of 94% gold, and the remainder being made up of small amounts of platinum, palladium, iridium, and other metals of the platinum group. It should be understood that the slimes when first recovered from the anodes tend to contain some undecomposed silver, etc., and require a short preliminary reduction and digestion in concentrated sulphuric acid.

Separation of Rare Metal Impurities.

The rich slimes are transferred to an improvised form of laboratory, where they are digested in *aqua regia* in a series of large glass flasks. The latter are placed on extensive hot plates heated by a series of gas burners. The operation is conducted in a large fume cupboard similar to those used for ordinary laboratory work. As a safety measure, a sloping floor is made in the cupboard, and also a gutter running the whole length of the erection, so that in the event of any spills or cracking of the flasks, all contents will be readily recovered below. The slimes dissolve with varying rapidity in the acid, depending on their composition. Small amounts of silver and lead prevent the hydrochloric acid of the *aqua regia* taking its full effect on the slimes, and it is usually necessary to remove the insoluble residue and dry it. The dark-brown mass is then transferred to a crucible and "grained" by melting and pouring into cold water. The small grains of metal are returned to the flasks and digested in nitric acid, which dissolves out the lead and silver with comparative ease. The solutions from these different digestions are filtered into a large stoneware vat. They contain practically all the gold, platinum, and palladium, whilst the other metals of the platinum group remain in the insoluble residue.

The combined liquors are directly treated with ferrous chloride, which, besides precipitating the gold completely, shows no evidence of bringing down any platinum or palladium in the form of traces.

Gold is thus precipitated as a dark-brown powder, and is filtered off and specially washed. It is sometimes necessary to employ acid washings which tend to dissolve a small amount of the gold in order to ensure that all traces of impurities are removed, and hydrochloric acid is quite frequently used. (These washings are later accumulated and treated with ferrous chloride as before, after which the impure gold thus recovered is returned to an earlier stage of the process.)

After drying the gold precipitate, it is placed in specially made crucibles. Plumbago pots did the work fairly well, but could not withstand the corrosive effects of the chlorine. The crucibles are placed in ordinary pit fires supplied with a good draught, and the residue slowly raised to melting point. As the residue is bulky, it is customary to add a second lot, when space in the crucible permits, as a result of the concentration. The molten gold at certain temperatures shows a bright green colour, similar to molten copper.

Sodium Carbonate in Iron and Steel Works

By N. L. Evans, B.Sc. A.I.C.

SODIUM carbonate, which is the anhydrous form of the familiar washing soda, is a chemical which has recently attracted a considerable amount of attention in this country and abroad owing to its efficiency as a cleansing flux and desulphurising reagent for cast iron and certain non-ferrous metals. It has a useful operating range of about 600° C., from its melting point at 851° C. up to 1,450° C. The range of metals which may be treated, therefore, includes copper, brass, bronze, and cast iron, and some new developments in its use in foundry practice described by Mr. Evans recently before the Sheffield branch of the Institute of British Foundrymen are of interest.

Considerable advantages have resulted from the use of sodium carbonate in its new form, known as "Granular Ash," and it being practically free from dust makes for greater economy in use. Sodium carbonate is also supplied in the form of fused blocks weighing 4 lb. each for use in a cupola. In describing their use in this connection, Mr. Evans mentioned that they are made primarily for addition to the cupola with the charge, and although, on account of the presence of siliceous slag, no very great reduction in sulphur normally takes place, the metal is kept free from non-metallic inclusions. Moreover, the cupola walls are kept very clean, so that the daily patching is much more easily carried out and ganisters saved.

One of the primary needs when any metal is used with a flux is to ensure efficient separation of the flux, so that it is not poured into the mould. With this in view, attention has recently been devoted to the development of the teapot type of ladle which embodies a syphon principle, the metal being drawn from the bottom of a ladle. Another device particularly adapted to mass-production foundries is the fore-hearth, an ideal place for carrying out the treatment of the metal with the sodium carbonate. The ordinary type of fore-hearth which is also used to preheat the blast is not satisfactory, but a new design has recently been put on the market which has a permanent opening in the top through which carbonate can be introduced.

A slag trap is fitted between the cupola and receiver, since it is most important to prevent siliceous slag entering the receiver. Siliceous slag has the effect of reversing the desulphurising reaction of sodium carbonate, with the result that sulphides of iron and manganese are re-formed and returned to the melt.

Mr. Evans quoted figures showing the reduction in sulphur normally obtained, and these emphasise the importance of carrying out the process in the absence of siliceous material. For this reason metal poured from a 500-ton tilting mixer which is drawn from below the slag level, gives an absolutely consistent sulphur reduction of 50%, whereas, if slag is allowed to become mixed with the soda flux, much less than 50% of the sulphur can be removed from the metal. An outline was also given of the precautions which should be observed to prevent soda slag attacking refractories.

Important Applications of the Process.

In referring to the process in connection with grey iron castings, the point was stressed that soundness and machinability are much more important, generally speaking, than tensile strength. The determination of the latter depends on the use of a test-bar, which seldom gives a true representation of the properties of the casting itself. Owing to its degasifying action, sodium carbonate helps to eliminate such defects as shrinkage cavities, gas holes, and the like, and by reducing the sulphur content and preventing segregation of this element, it ensures a casting which can readily be machined. The sodium carbonate process is specially recommended for cast-iron chemical plant ingot moulds and chilled rolls.

So far as Tropenas steel castings are concerned the process is in almost universal use in this country. Not only does the removal of sulphur make the choice of raw materials much wider, but the removal of non-metallic inclusions from the metal results in a very high ductility in relation to the tensile strength. The process is also used for treating iron from the blast-furnace or mixer for making Bessemer and open-hearth steel.

Reference was also made to the possibility of using sodium carbonate in the basic open-hearth furnace. Work by Lowry in America has shown the advantage of using a mixture of sodium carbonate and fluorspar instead of fluorspar alone, and it is suggested that this may have a profound effect upon the value of the resulting slag as a fertiliser.

Brief reference was made to the work which is still in the experimental stage on the catalytic effects of sodium carbonate, firstly in accelerating the rate of production of iron ores, and secondly in increasing the efficiency of gas producers, directed towards the production of a gas containing less undecomposed steam and carbon dioxide and more carbon monoxide and hydrogen.

Application of Non-ferrous Metals.

The value of sodium carbonate in connection with non-ferrous metal founding is also noteworthy. In melting brass and bronze, for instance, swarf deoxidation is necessary, and it is essential that the entrained oxides should be removed from the melt before casting. Sodium carbonate has been shown to be one of the most suitable reagents for this purpose, since it forms a very fluid slag, and is not unduly volatile at the temperature of molten brass. The principle involved in this is, of course, exactly the same as that whereby oxides, silicates, and sulphides are removed from cast iron.

Present-day Gold Refining

(*Continued from page* 157).

Despite all the precautions taken, minute amounts of base metals remain in the gold, and to account for them a stream of chlorine gas is led into the crucible from a cylinder. Best results were secured by using a silica tube for adding the gas. Experience showed that a slow stream containing comparatively little gas sufficed.

The great density of gold makes it necessary to introduce the chlorine at a fairly high pressure, and this has to be manipulated so that an undue excess of gas is not added. In actual practice, it was found that gold could be lost by adding too much chlorine, which refutes the earlier contention that no loss could be sustained in this way. Zinc, lead, copper, antimony, and bismuth are converted to chlorides and volatilised, leaving no trace of their presence, and finally silver is removed. The silica tube is then disconnected, and the gold allowed to remain molten for a few minutes to dispel any remaining gas, and then tapped into an ingot mould. On solidifying from the molten condition, the colour of gold changes from green to brown, then reddish, and finally develops its characteristic yellow hue.

The ingots whilst still warm are pickled in dilute hydrochloric acid to remove any skin or scale from the surface, when they are ready for the market.

Recent Developments in Tools and Equipment

Much progress is being effected in rolling-mill plants, particularly in the type of drive used and in the development of strip rolling mills. Electric driving is being applied to an increasing extent, while higher speeds are being adopted for strip rolling.

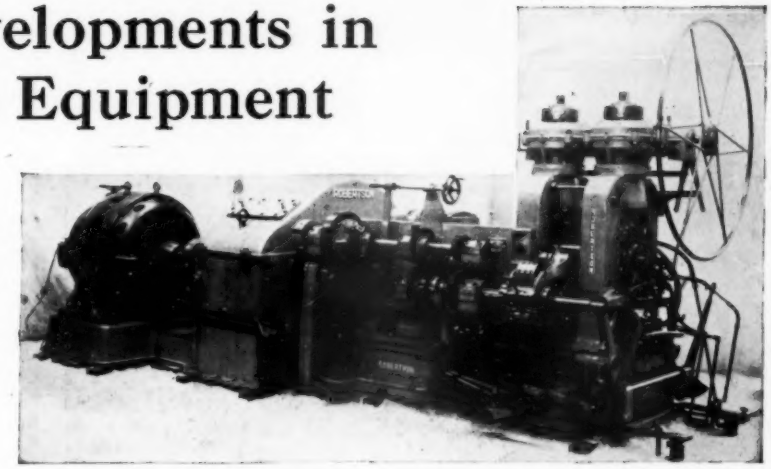


Fig. 2—High-speed two-high mill for cold-rolling brass strip in widths up to 8-ins.

Rolling-mill Plant.

THE gradual improvement in the metallurgical trades, particularly during the second half of last year, has influenced development in plant and equipment, notably in the application of electric power to many types of machines in operation. Thus, for instance, Metropolitan-Vickers Electrical Co., Ltd., have in hand an 1,100 h.p. slip-ring induction motor for John Lysaght, Ltd. It is to be coupled to a single reduction gear drive, provided with two overhung flywheels having a storage energy of 26,000 h.p.-secs., at 250 r.p.m. The motor is being provided with a rotary type phase advancer and slip regulator for improving the power factor of the set to practically unity, and at the same time providing the necessary speed drop to enable the flywheel to deliver the required stored energy. Blast-furnace equipment has been installed in some plants, these equipments being fully automatic sequenced hoists, including bells, distributor sounding rods and signals.

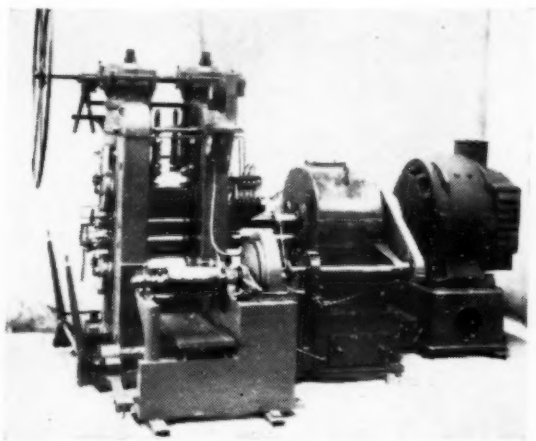


Fig. 1— Four-high rolling mill for cold-rolling steel strip 10-ins. wide.

Amongst recent designs of mill plant, mention may be made of the latest small four-high rolling mill, by W. H. A Robertson and Co., Ltd., designed for cold-rolling steel strip up to 10 in. wide. The working rolls, of hardened chrome steel, are 6 in. diameter and 12 in. face, are supported by large diameter backing rolls, also of hardened steel, running in roller bearings. This mill, shown in Fig. 1, is self-contained, and is driven by a variable-speed motor, giving rolling speeds from 100 to 300 f.p.m. A powerful coiler, with adjustable friction clutch for regulating tension, is included. All lubrication is automatic, and special provision is made for adequate cooling. A mill of this type, similar in construction, but for cold-rolling steel strip in all qualities up to 17 in. wide, was recently installed and put into operation in the Sheffield district. Similar mills are being supplied for reversible working, with which coilers are supplied both sides of the rolls, the strips being rolled backwards and forwards in a succession of passes without intermediate annealing or handling.

Fig. 2 shows the latest high-speed two-high mill, designed by the same company for cold-rolling brass strip from about 0·060 in. thick down to 0·004 in. and thinner, in widths up to 7 in. or 8 in. This mill embodies many important improvements developed during the past year or two. The rolling speed is 300 f.p.m., and by means of automatic coiling equipment the strip is wound direct from the rolls on to the coiling drum without handling by the operator.

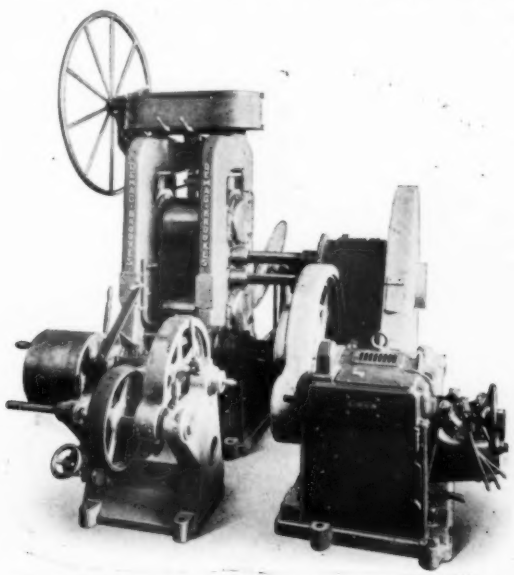


Fig. 3—"Demag-Brookes" four-high cold strip rolling mill.

Recent tests have shown that thin strips can be reduced in one pass from 0·010 in. to 0·005 in., and also from 0·008 in. to 0·004 in., and the finished strip proved to be perfectly flat and uniform in thickness, both across the width and from end to end of long coils.

Another four-high cold strip rolling mill is the "Demag-Brookes" product, built under licence by Brookes (Oldbury), Ltd. A mill of this type with working rolls 140 mm. diameter by 300 mm. width of face, is shown in Fig. 3.

Fig. 4.—Plate-bending machine for rolling complete cylinders up to 27-ft. long with plate 1-in. thick.

The roll housings are of cast steel, with steel chocks and the control of the top roll is by means of large handwheel and gearing, all the gearing being enclosed in a case, while a scale ring shows the actual adjustment. The methods for cooling both the working and backing rolls are of interest. For this purpose a cooling liquid is taken from a tank by means of a pump and circulated through cooling fittings pressed on the rolls and then through a special cooling unit, where it is reduced to normal temperature.

Large Plate-bending Machine

AN outstanding development in plate-bending machines is a large machine of the three-roll type recently designed and constructed by Joseph Foster and Sons, Ltd. It is designed for rolling complete cylinders up to a maximum of 27 ft. long, with plate 1 in. thick. Separate motors are fitted for driving and adjusting the height of the top roll.

The main motor starts and stops each time a plate is passed through the machine, and a solenoid brake is fitted to ensure quick stopping when the current is cut off. The roll adjusting motor runs continuously when the machine is in use, top roll adjustment being made by hand-operated friction clutches, one being placed beside each main frame. By this means the top roll is very accurately adjusted both for height and to be parallel to the bottom roll. The adjusting gear is made foolproof by fitting a limit switch at each adjusting screw. These switches cut off the current to the adjusting motor and prevent the top roll travelling beyond its maximum top or bottom positions.

In order to allow of the removal of the completed cylinder from the machine, the bearing for the top roll furthest from the driving gear is made to swing outwards, and the unbalanced weight of the top roll is taken by the extension piece on the roll. The swing bearing is balanced by two weights acting through a horizontal spindle, and can easily be moved by hand in all positions.

The two lower rolls are supported by two sets of supporting rollers, which transmit the stress due to bending to the foundation girders, thus practically eliminating deflection of the bottom rolls. To neutralise deflection of the top roll, it is made larger in the centre, and tapered down towards the ends. The foundation girders are built up of heavy steel plate and form supports for the bottom rolls without depending on the foundations in any way. The machine, which is shown in Fig. 4, has an overall length of 50 ft. 7 in., and a maximum width of 10 ft. 7 in. The diameter of top roll is 28 in., and of bottom rolls 16 in.

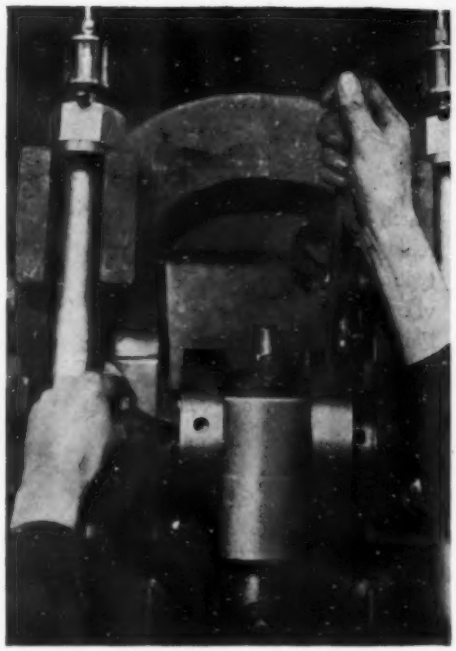


Fig. 5.—Small-type press with six different strokes.

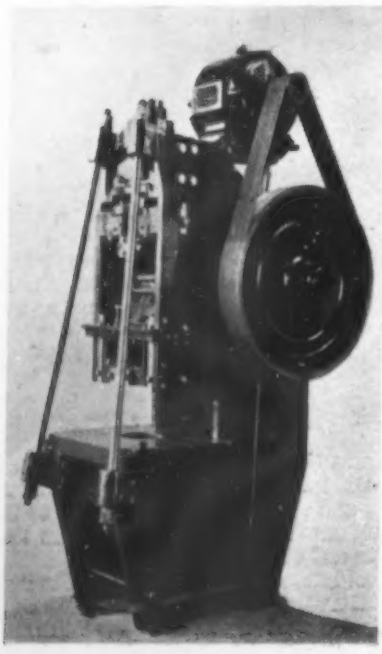


Fig. 6.—The Humphris 60-ton open-fronted ungeared press with motor mounted on an adjustable table, with Texrope drive.

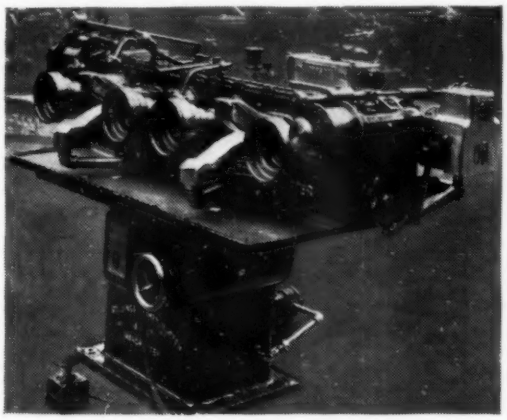
Press Machines.

SOME noteworthy improvements have been made in press machines, and it is of interest that the latest design of adjustable stroke is fitted to the standard 6-ton press designed and built by Taylor and Challen, Ltd., although designs exist for crankshafts of this type for presses of up to 100 tons capacity, and some double-crank presses. Six different strokes are available in the small type referred to, which allows a variation at ½ in. intervals between ½ in. and 3 in. The alteration is carried out simply by changing a single key, as shown in Fig. 5.

Several types of presses have also been developed by Mass Products, Ltd., which have several interesting features, these cover a range varying in capacity from 100 tons to complete mechanisms of the bench type, one type being illustrated in Fig. 6.

Wire Machinery.

UNTIL comparatively recent times, the single-hole wire-drawing block was universally employed for the manufacture of wire of all sizes. This consisted of a power-driven metal drum mounted on a vertical spindle which drew the wire through the die, the drawn wire being wound on the drum until the end of the coil was reached. The drum was tapered towards the top to facilitate removal of the drawn wire. Recently, however, there was a very important change in wire-drawing procedure, which brought into being continuous wire-drawing machines of various types, and at the present time the production of nearly all kinds of wire in various sizes is carried out on such machines. In these machines the wire passes through a succession of dies, the number of dies employed usually being limited only by the amount of reduction possible before the wire requires annealing. Power-driven drums are employed between the dies to pull the wire through the appropriate dies. The speeds at which these drums revolve increase as the wire becomes thinner, in order to provide for the elongation caused by drawing.



A new fine wire machine for drawing all classes of wire from 40 to 50 gauge.

More recently still, very important developments have taken place in continuous wire-drawing machines. These have been brought about by improvement in design, in the quality of material to be drawn, better attention to lubrication, improved die technique, both as regards material and design, and all these factors have enabled manufacturers to give bigger draughting and higher speeds, and at the same time to improve the quality of the finished wire.

Of these developments mention may be made of a fine wire machine for drawing all classes of wire from 40 gauge down to 50 gauge, which has been produced by the firm of Sir James Farmer Norton and Co., Ltd. This incorporates features not contained in the usual machine of this type. The makers contend that for such wires as copper and phosphor bronze an 18-die machine is a much more economical proposition than machines having only 12 dies. Furthermore, owing to the complete elimination of idlers, the usual overhang of the cones can be reduced to a minimum, since each cone on the machine is a drawing cone, the steps of the cones not requiring to be as large as the usual machines. The extra threading time taken to thread the extra dies is negligible, even if the wire should inadvertently break, since it is found in practice that breakages occur most frequently on the finer end of the machine, the threading of the dies at the finishing end only being required.

A very interesting innovation has been incorporated in the spooling gear. Realising the disadvantages associated with the existing methods of mechanically controlling the speed of the finishing spool, this firm has, after extensive experiments, perfected and patented an electrically controlled spooling device which is based on the principle of constant tension of the wire. The reel shaft is so driven that any slight additional load imposed on it causes the reel to slow down corresponding to the applied load. Since the bobbin is connected direct to the wheel-shaft the gradual increase in torque due to the ever-increasing diameter of the bobbin is compensated by the decrease in the revolutions of the reel spindle. Actually, this method promises to revolutionise the existing methods of spooling on all types of machine.

For a considerable time it has been realised in the trade that existing methods depended too much on the human element, and considerable adjustment was required to wind bobbins having constant tension, particularly when it was required to wind slack spools for annealing purposes. This method eliminates all ratchet wheels, cone pulleys, and other mechanical devices, and requires no adjustments during operation. Any diameter of spool can be used without making adjustment.

One of the most important features of this machine is the traverse, which is designed to function horizontally. Other makes of machines utilise a traverse depending upon a swinging arm. The wire has consequently to traverse on an arc whilst the winding on the bobbin is horizontal, and in a straight line. This causes additional tightness at the centre of the spool, due to the wire being stretched excessively during the motion of the traverse lever. Straight-line traverse overcomes this and provides an even lay on the spool.

A glance at the illustration will suffice to indicate the balancing of the tension of the traversing dieholder. Tensions due to the construction are equal and opposite, and not in the same direction as is the case with machines where idler cones are employed. Rigidity is, of course, essential in machines of this type, and special precautions have been taken to ensure that the general design is well balanced and without vibration. In accordance with modern methods, the machine is fitted with its own motor, the machine thus being a self-contained unit. The special cones have been eventually developed after much research and experimenting, and are dynamically balanced. In the trade it has been felt that belt drives and other methods could be improved upon, and it is very interesting to note that a machine has been developed in which the drive consists of special nickel-chrome spiral bevels.

Protection of Steel Pipe Lines.

Machine Coating with Bitumen on the Site.

THE well-known advantages of steel for pipe-line work in competition with both cast-iron and cement-fabricated pipes of the ferro-concrete and cement-asbestos varieties are considerably enhanced by the efficient methods now available for effective protection against rust and corrosion. These depend upon the use of bitumen, which by one general method can be applied to the very hot pipe immediately after manufacture. If further protection is necessary this can be provided by bitumen-saturated jute cloth or by a sheathing of tough seamless bitumen composition. The coating of the pipe surface can also be carried out on the site by hand, using brushes, but in this connection an important new bitumen pipe-coating machine has been developed in the United States, which enables the operation to be undertaken in a much more convenient, efficient, and rapid manner, with also negligible loss of bitumen.

This pipe-coating machine consists essentially of two short cylindrical sections, one fixed inside the other, rigidly joined together, which are fitted round the pipe, being split longitudinally for opening and closing by means of a hinge and latch. The whole apparatus is light and small in size, being, for example 1 ft. 9 in. outside diameter and 2 ft. long, weighing 90 lb. for a 10-in. pipe, being provided also with a hopper for the bitumen. Included is a series of small wheels, so that the apparatus can be caused to travel along the pipe by hand, and a heating arrangement of burners, operated by cylinders of compressed gas,

so as to keep the bitumen very hot, about 200° F. and in the thoroughly molten condition. The bitumen passes out in a continuous stream and gives a uniform coating of any desired thickness to the whole surface of the pipe, while any surplus is caught underneath for return to the hopper.

It is claimed that with the complete field equipment provided and a gang of 16 men over 9 miles of 10-in. steel pipe-line can be coated with bitumen per 9-hour shift in a manner not possible by the much slower and most costly hand methods.

Steel, it will be remembered, has many good qualities for pipe-line work, especially as against cement construction, being, for example, relatively light, available in long lengths up to 40 feet, which reduces the number of joints, and unbreakable. Also steel has a very high tensile strength, so that pipe-lines of this character can operate at 3,000 ft. head and over, while a burst pipe is almost unknown. In addition, steel is elastic, allowing the pipe-line to bend to a considerable degree, and is absolutely non-porous, so that, for example, water supply cannot be contaminated from the surrounding soil.

Glass Silk for Heat Insulation

Glass silk, it is claimed, has all the qualities of an ideal insulator and no material equals it in the combination of low conductivity, light weight, resistance to vibration, resistance to high temperatures, and the power to retain these properties during constant use.

ONE of the new industries developed during the last year or two is the manufacture of spun glass, or glass silk. This consists of very fine threads or fibres of glass which are very flexible, and can be made up into many forms suitable for heat-insulators. Glass silk has all the qualities essential to an ideal non-conductor of heat, and by its use many of the disadvantages which attend the use of other forms of insulation are avoided. The threads possess a surprisingly high tensile strength, and when spread into the various forms suitable for heat insulation produce a network of fibres highly resistant to vibratory influences, which is such an important consideration in engineering practice.

It has long been known that still air forms an almost perfect heat insulator, but, in practice, it has been found impossible to take advantage of the solution which the apparent simplicity of this fact may suggest. Means must be found to imprison the air in such a way that under changing temperature conditions it will remain stationary for all practical purposes. With diatomaceous earths and other similar porous substances advantage is taken of the minute air cells which constitute the pores in their structure, and in order to bind the material together for the purposes of practical application fibrous substances are added. This introduction of extraneous matter, which in itself possesses relatively low powers of resistance to heat flow, tends to detract from the efficiency of the whole. It is claimed that glass silk, with its long, fine silken fibres, offers a solution. With this material the air cells are imprisoned between the threads, which when spread into the various usual forms lie closely together, and since they can be switched and possess a natural tendency to cling together in network formation, the addition of binding materials is quite unnecessary.

Glass silk is quite incombustible, and is claimed to withstand temperatures as high as 900° F. It has been tested and proved up to a temperature as high as 1,100° F Consisting solely of glass, it is rotproof, and offers no sustenance to vermin, and neither causes corrosion nor is it attacked by any chemical, with the exception of hydrofluoric acid. It is chemically inert, and will not affect materials with which it comes in contact, nor will it be affected by them.

This material is claimed to have a coefficient of thermal conductivity at least as low as any other material suitable for steam temperatures, and lower than most, while no material equals it in the combination of low conductivity, light weight, resistance to vibration, resistance to high temperatures, and the power to retain these properties indefinitely during constant use.

The results of tests carried out on an electrically heated pipe covered with glass silk in various thicknesses are shown in Fig. 1. The temperatures used range from 200° to 900° F. The curve showing heat losses from the bare pipe should be read on the higher scale, and those from insulated pipes on the lower scale.

This heat-insulation material, which is manufactured by Chance Bros. and Co., Ltd., can be made up into various forms according to the nature of the surface to which it is applied. It is simple to apply and is not affected by the

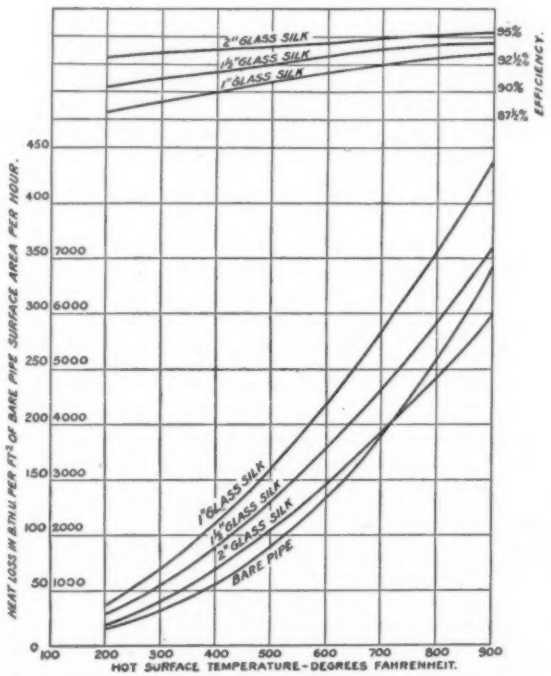


Fig. 1.—Results of tests to show the heat insulating value of glass silk.

expansion and contraction of surfaces to which it is applied. It may be used in the ravelled condition for packing into enclosed spaces; as sheets for large surfaces, such as tanks, large diameter pipes, etc.; as mattresses made up to special sizes and shapes, according to the purpose for which they are required; and as strips for covering pipes. The thickness necessary for satisfactory insulation depends upon the size of the container and its temperature, and may vary from ½ in. to 2 in. In some forms it can, if necessary, be removed and refixed quite satisfactorily, and still retain its original efficiency.

Business Notes and News

Steel Works Plant and Equipment.

Ashmore, Benson, Pease and Co., Ltd., have completed an agreement with the Pennsylvania Engineering Corporation, of New Castle, Pennsylvania, the purpose of which is the manufacture by the former company of steel-works plant and equipment according to the design and drawings of the American company, as well as upon the basis of their experience. The reputation of Ashmore, Benson, Pease and Co., Ltd., which extends over many years as designers and builders of plant, is well known, and the effect of the collaboration between these two responsible companies will be to place at the disposal of the British steel industry sound and reliable experience in the design and construction of modern steel-works plant. They offer expert consultative service in all problems concerning such plant and equipment as duplex steel plants, Bessemer converters, cupolas and their equipment, stationary and tilting open-hearth furnaces, hot-metal mixers, hot-metal cars, etc.

High-frequency Electric Furnace Steel.

An indication of the rapid progress being made in the application of the high-frequency furnace for special steels is shown by the achievement of Samuel Fox and Co., Ltd., Stockbridge, Sheffield, associated with the United Steel Companies, Ltd., in manufacturing 2-ton ingots. The high-frequency electric furnace is used for the production of special alloy steels of the highest possible quality and purity, which formerly were made entirely by the crucible process, but the ingots made have been invariably less than 2 tons in weight.

With the use of the high-frequency electric process there is no pick-up of impurities, and the freedom from non-metallic inclusions renders the process particularly suitable for the production of alloy steels used for parts which are to be subjected to high stresses. Experiments carried out with various grades of steel manufactured in the high-frequency furnace at the works of Samuel Fox and Co. have given very satisfactory results, and to widen the application of the use of the high-frequency electric process this progressive firm is at present installing a furnace capable of producing ingots 5 tons in weight.

Technical Training for Foundrymen.

Further to the promotion of a degree course in founding at Sheffield University, an important development is now in contemplation with a view to greater concentration on the technical training of foundrymen. The proposal under consideration is the establishment of a national foundry school. This has been advocated for some time past, and it is noteworthy that it is now taking tangible form. A scheme has been drawn up for such a school located in the Midlands, at which a year's instruction would be available to those already in the industry who could take advantage of it.

The proposal emanates from the British Cast Iron Research Association, and has the official support of the Board of Education. It is to cover not only grey iron, malleable iron and steel, but non-ferrous foundry work also. The idea of the promoters is that the enterprise should be governed by a body representing the scientific, technical, and trade associations in the industry.

It is gratifying that some attention is being directed to the proper training of foundrymen, for foundry practice has changed considerably during recent years as a result of metallurgical developments and the stringent demands of the engineer. The production of sound and accurate castings has always demanded more than average intelligence and skill, but with increasing knowledge and keen international competition it is essential that training facilities should be available at least as efficient as those constituted for the training in other industries, and it is to be hoped that the efforts now being made will have the full support of the founding industry.

A contract for the supply of armaments and munitions to the Portuguese Navy has been signed in Lisbon by a representative of Vickers, Ltd., and Commander Guimaraes, the Portuguese Minister of Marine. This contract covers the supply of £79,170 worth of armaments and munitions for the new Portuguese torpedo boats *Tejo* and *Douro*.

Naval Construction Programme.

Provision for four cruisers, a flotilla leader, and eight destroyers, an aircraft carrier, three submarines, and other smaller craft, together with the modernisation of capital ships, is made in the Navy Estimates for 1934. Three of the cruisers are to be of the *Minotaur* type, and the remaining one of the *Arethusa* type. Of the three submarines, one is to be a mine-layer and two of "S" or patrol type. The smaller craft includes two general service sloops, two sloop mine sweepers, one net layer, two coastal sloops, and one surveying ship.

It is stated, with reference to the 1933 programme, that orders for the two new type cruisers of about 9,000 tons (*Minotaur* and *Polyphemus*), to be built by contract will be placed about June next. The order for the construction of the *Penelope*, a third cruiser of the *Arethusa* class, is being placed with Harland and Wolff (Belfast). An order for the construction of the flotilla leader *Grenville* will shortly be placed with Jarrow and Co. (Scotstoun), and orders for the eight destroyers will be placed as follows:—*Greyhound* and *Griffin* with Vickers-Armstrong (Barrow-in-Furness); *Gallant* and *Grenade* with A. Stephens and Sons (Linthouse, Govan); *Grafton* and *Glowworm* with J. I. Thornicroft and Co. (Southampton); and *Garland* and *Gypsy* with Fairfield Shipbuilding and Engineering Co. (Govan). The minelaying submarine *Grampus*, deferred from the 1932 programme, will be built at Chatham Dockyard. The order for a further vessel of this class, the *Narwhal*, is being placed with Vickers-Armstrong, and the order for a vessel of the improved *Swordfish* class, the *Seawolf*, with Scott's Shipbuilding and Engineering Co. (Greenock). Construction of the sloop *Londonderry*, of the 1933 programme, is to begin at Devonport Dockyard immediately. The order for the sloop *Speedwell*, a sloop minesweeper, is being placed with William Hamilton and Co (Port Glasgow).

New Seamless Steel Tube Factory.

A new factory is being erected at Sparkbrook (Birmingham) for the English Seamless Tube Co., Ltd. The building, when completed, will occupy about 30,000 sq. ft., and will be used for the production of hot finished weldless steel tubes, which form the raw material for the manufacture of cold-drawn boiler tubes produced by the associated company, the Universal Steel Tube Co., Ltd., whose entire supplies up to the present have been imported from Sweden. In future it will be possible for both companies to utilise British steel entirely for their productions instead of importing from abroad. The plant to be installed is of an entirely new type recently developed by one of the leading American tube manufacturers, from whom a licence has been obtained. The whole machinery is at present being built at Wolverhampton, and it is anticipated that when the installation is in proper working order hot finished tubes of a greatly superior quality, as compared with those at present marketed in this country, will be obtainable.

Refuelling the Graf Zeppelin.

The giant *Graf Zeppelin*, which burns gas instead of gasoline, has a fuel gas capacity of 900,000 cub. ft., giving her motors a cruising radius of 6,000 miles at 65 miles per hour. At the refuelling in Akron about 750,000 cub. ft. of fuel gas was taken on board. Sixteen hours were required for the operation.

The fuel gas used by the *Graf Zeppelin* is composed of approximately 65% Pyrofax and 35% hydrogen, and has a specific gravity of 1.05. Pyrofax gas is introduced into one end of the piping lay-out and the hydrogen into the other end. These gases are mixed at a common outlet and then flow through a tunnel into the air dock. Liquefied Pyrofax from the tank car is passed through a steam vaporiser, the steam being provided from the railroad locomotive on the siding. The hydrogen is brought in through a manifold connection and thence through a main control valve. To maintain the temperature of the two gases constant and thereby eliminate the necessity for making corrections for flowing temperature, the hot Pyrofax gas from the vaporiser is cooled by refrigeration and the hydrogen is heated.

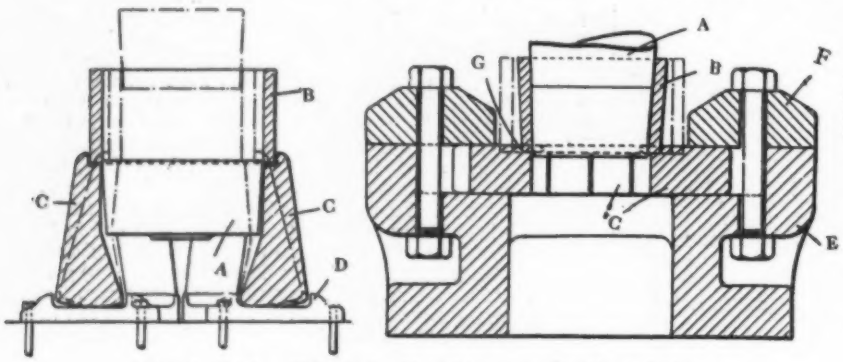
PERSONAL.

Vickers, Ltd., announce that Mr. Arthur Terence Maxwell, a partner in Glyn Mills and Co., was appointed a director of the company at the board meeting held on March 8, 1934.

The directors of Vickers, Ltd.., recommend, for approval in general meeting, a dividend for the year 1933, at the rate of 4%, less income-tax, on the ordinary shares of the company. This dividend, if approved, will be paid on Wednesday, April 4, 1934.

Some Recent Inventions.

The date given at the end of an abridgment is the date of the acceptance of the complete Specification. Copies of Specifications may be obtained at the Patent Office, Sale Branch, 25, Southampton Buildings, London, W.C. 2, at 1/- each.



Figs. 1 and 2.—Method of cold-working non-magnetic steel rings.

Cold-working Non-magnetic Steel Rings.

IT is well known that the cold-working of non-magnetic steels results in change in their physical properties, and in particular, in the raising of the elastic limit and yield-point to an extent not attainable with any form of heat-treatment at present known. Stress is induced in one process by forcing through the ring or cylinder a mandrel or ring-plate of suitable size, by which the diameter of the ring is enlarged. An improved method has been devised by which the ring or cylinder is supported during the expanding process. The means provided consists of a series of segments, each of which is recessed to support the ring. A sectional elevation of the arrangement is shown in Fig. 1, in which the mandrel A has passed through the ring B, which is supported by segments C. The necessary radial motion of the segments is allowed for by their being mounted on sole plates D across the surface of which they are adapted to roll, the lower surface of each segment being shaped as indicated. In an alternative arrangement, the upper surface of each sole-plate is formed to constitute a cylindrical bearing in which the segment may rock by partial rotation as the ring expands.

A modification of the method is shown in Fig. 2, in which the supporting segments C are arranged to slide radially on a circular frame or bedplate E, being retained in position by a securing ring F fitted with bolts to the frame. Due to the accommodation of the ring B in recesses G, the segments will slide outwardly as the ring is expanded, by insertion of the mandrel A. In a further modification the ring or cylinder is supported by spring-controlled bell-crank levers.

395,428. ENGLISH STEEL CORPORATION, LTD., and J. H. S. DICKINSON, and G. S. CLEGHORN, all of Sheffield. July 20, 1933.

Annealing Steels and Alloys.

A PROCESS has been developed for treating steels and alloys capable of taking and retaining a bright surface. It is particularly applicable to stainless steels and alloys containing nickel, such as the corrosion or heat-resisting nickel chromium stainless steels containing, for example, 18% chromium and 14% nickel, or nickel-chromium alloys containing a high percentage of nickel, such as those containing about 88% nickel and 12% chromium, but is also applicable to other alloys, such as nickel-iron alloys.

Normally the annealing of such alloys leads to detrimental discoloration of the surface due to oxidation. By the process developed bright-surfaced annealed products are produced by first imparting a bright surface to the alloy, which may be in any form, such as cold-rolled sheets or strips. The surface of the alloy is then rendered passive, such as by heating in a nitric acid solution of from 5 to 30% concentration for from 15 to 60 mins. at a temperature between 160° and 200° F. Annealing then takes place for several hours at a temperature between 1,650° and 2,000° F., but preferably between 1,650° and 1,800° F.

In this process the material is annealed in a nickel-lined muffle furnace in which a reducing atmosphere is maintained. This atmosphere need not be completely free from water vapour, and various reducing gases may be employed. Dry hydrogen is preferred, but mixtures of carbon monoxide and hydrogen; carbon monoxide, hydrogen and nitrogen; or carbon monoxide, carbon dioxide, hydrogen, and nitrogen may be employed. The period of heating at the preferred temperature may be between two and two and a half hours.

399,049. THE MOND NICKEL CO., LTD., Millbank, London, S.W. September 28, 1933.

Unique Bridge over the Tees

The first of its kind in this country and the largest of its type in the world is the description given by the Duke of York of the new Tees (Newport) bridge, which he formally opened at Middlesbrough recently. The bridge to which he referred is really a gigantic lift, the opening span, which carries the roadway, being slung from wire ropes that pass over wheels at the tops of the main towers, and fastened to counterweights equal in weight to the bridge. It has a span of 274 ft. 6 in., the carriage way is 38 ft. wide, and there are two footpaths each 9 ft. wide.

When raised, a clearance of 120 ft. above high water ordinary spring tides is afforded and an uninterrupted navigable channel 250 ft. wide is available for shipping. The moving mass when the span is being raised is 5,000 tons; the next largest vertical lift bridge involves a moving mass of not quite 2,000 tons.

There are really two unique bridges in the scheme, for in addition to the main span an all-welded bridge carries the north approach road over the railway. It is the largest all-welded bridge in the country.

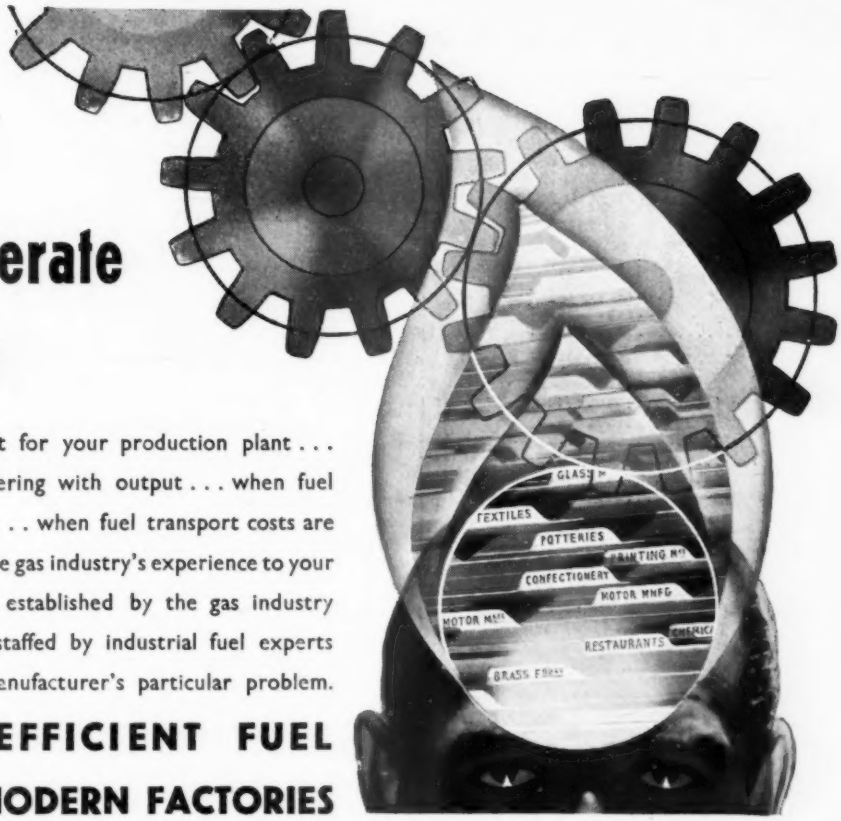
Heat-treatment Tables.

Edgar Allen and Co., Ltd., Imperial Steel Works, Sheffield, has sent us a rather unique type of publication. This consists of a series of steel selection and heat-treatment tables, arranged in such a way as to provide maximum facility of reference. The steels dealt with are our high-speed steels, corrosion-resisting steels, permanent magnet steels, steels for motor-cars and aircraft, carbon tool steels, and special alloy tool steels. For each class of steel a list of the different types is mentioned with purposes and heat-treatments, while wherever essential analyses and charts of mechanical properties are included. An interesting feature is the inclusion in this set of tables of business reply cards, to enable the recipient to apply for supplementary literature dealing with any steel in which he is interested. The whole sets of tables are mounted on card and strung for hanging on the shop wall. We are informed that a copy will be sent to interested steel users on application.

The second blast-furnace of the Azov Steel Trust has recently been put into operation. This makes the 111th blast-furnace in the Soviet Union. The new furnace is completely mechanised. Its volume is 930 cu.m., and its output capacity is 775 tons of pig iron daily. The furnace was charged on February 17, and on that day produced 32 tons of high quality pig iron.

We understand that Messrs. David Brown and Sons, Ltd., gear manufacturers, of Huddersfield, have just installed another "Shorter" process gear-hardening machine, to be operated under licence, from the Patent Gear and Metal Hardening Co., Ltd., of 69, Horseferry Road, London, S.W. 1.

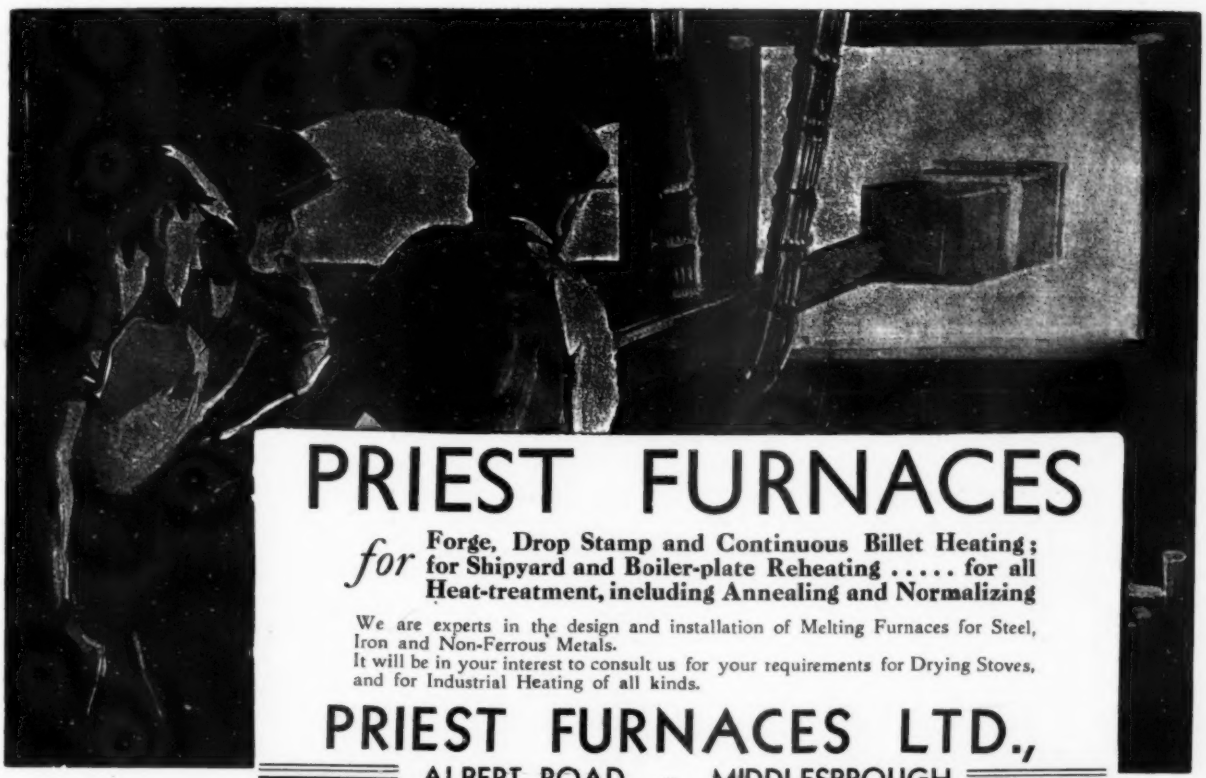
Let the Gas Industry's Research Accelerate your Production



When you need cheap, efficient heat for your production plant . . . when there are fuel problems interfering with output . . . when fuel storage space is increasing overheads . . . when fuel transport costs are mounting . . . that's the time to bring the gas industry's experience to your factory. Research stations are being established by the gas industry in many industrial areas. They are staffed by industrial fuel experts who are ready to investigate the manufacturer's particular problem.

GAS THE EFFICIENT FUEL FOR MODERN FACTORIES

Ask for the advice of your gas undertaking or write to The British Commercial Gas Association, 28 Grosvenor Gardens, S.W.1



PRIEST FURNACES

for **Forge, Drop Stamp and Continuous Billet Heating; for Shipyard and Boiler-plate Reheating ..... for all Heat-treatment, including Annealing and Normalizing**

We are experts in the design and installation of Melting Furnaces for Steel, Iron and Non-Ferrous Metals.
It will be in your interest to consult us for your requirements for Drying Stoves, and for Industrial Heating of all kinds.

PRIEST FURNACES LTD.,

ALBERT ROAD :: MIDDLESBROUGH

'Phone: Middlesbrough 3981. *'Grams: "Priest, Middlesbrough"*

MARKET PRICES

ALUMINIUM.

98/99% Purity	£100	0	0

ANTIMONY.

English	£39 10 0 to £40	0	0
Chinese	£31 0 0 to 32	0	0
Crude	22	0	0

BRASS.

Solid Drawn Tubes	lb.	9d.
Brazed Tubes	„	11d.
Rods Drawn	„	8⅜d.
Wire	„	7⅜d.
*Extruded Brass Bars	„	4¼d.

COPPER.

Standard Cash	£32	12	0
Electrolytic	36	0	0
Best Selected	35	10	0
Tough	35	0	0
Sheets	64	10	0
Wire Bars	36	5	0
Ingot Bars	36	5	0
Solid Drawn Tubes	lb.		10d.
Brazed Tubes	„		10d.

FERRO ALLOYS.

‡Tungsten Metal Powder	lb.	0	2	10
‡Ferro Tungsten	„	0	2	7
Ferro Chrome, 60-70% Chr. Basis 60% Chr. 2-ton lots or up.				
NOMINAL 2–4% Carbon, scale 11/- per unit	ton	33	2	6
NOMINAL 4–6% Carbon, scale 7/- per unit	„	23	0	0
NOMINAL 6–8% Carbon, scale 7/- per unit	„	22	10	0
NOMINAL 8–10% Carbon, scale 7/- per unit	„	22	10	0
§Ferro Chrome, Specially Refined, broken in small pieces for Crucible Steelwork. Quantities of 1 ton or over. Basis 60% Ch. Guar. max. 2% Carbon, scale 11/0 per unit	„	34	5	0
Guar. max. 1% Carbon, scale 12/6 per unit	„	36	10	0
§Guar. max. 0·7% Carbon, scale 15/- per unit	„	39	2	6
‡Manganese Metal 97–98% Mn.	lb.	0	1	4
‡Metallic Chromium	„	0	2	5
§Ferro-Vanadium 25–50%	„	0	12	8
§Spiegel, 18–20%	ton	7	10	0
Ferro Silicon— Basis 10%, scale 3/- per unit	ton	6	5	0
20/30% basis 25%, scale 3/6 per unit	„	8	2	6
45/50% basis 45%, scale 5/- per unit	„	11	17	6
70/80% basis 75%, scale 7/- per unit	„	18	10	0
90/95% basis 90%, scale 10/- per unit	„	30	0	0
Silico Manganese 65/75% Mn., basis 65% Mn.	„	13	15	0
§Ferro-Carbon Titanium, 15/18% Ti	lb.	0	0	4½
Ferro Phosphorus, 20–25%	ton	15	18	0
§Ferro-Molybdenum, Molyte	lb.	0	5	6
§Calcium Molybdate	„	0	5	4

FUELS.

Foundry Coke—			
S. Wales	—	1	7	6
Scotland	—	1	8	0
Durham	1 1 0 to	1	5	0
Furnace Coke—				
Scotland	—	1	5	0
S. Wales	0 17 6 to	0	18	6
Durham	—	0	18	0

GUN METAL.

*Admiralty Gunmetal Ingots (88 : 10 : 2)	£53	0	0
*Commercial Ingots	41	0	0
*Gunmetal Bars, Tank brand, 1 in. dia. and upwards	lb.	0	0	9
*Cored Bars	„	0	0	11

LEAD.

Soft Foreign	£11	9	0
English	13	0	0

MANUFACTURED IRON.

Scotland— Crown Bars, Best	£10	5	0
N.E. Coast— Rivets	10	15	0
Best Bars	10	5	0
Common Bars	9	5	0
Lancashire— Crown Bars	9	0	0
Hoops £10 10 0 to	12	0	0
Midlands— Crown Bars	9	12	6
Marked Bars	12	0	0
Unmarked Bars from	7	5	0
Nut and Bolt Bars £6 15 0 to	7	10	0
Gas Strip	10	12	6
S. Yorks — Best Bars	10	15	0
Hoops £10 10 0 to	12	0	0

PHOSPHOR BRONZE.

*Bars, "Tank" brand, 1 in. dia. and upwards—Solid	lb.	9d.
*Cored Bars	„	11d.
†Strip	„	10½d.
†Sheet to 10 W.G.	„	11d.
†Wire	„	11⅞d.
†Rods	„	11d.
†Tubes	„	1/4
†Castings	„	1/1½

†10% Phos. Cop. £30 above B.S.
†15% Phos. Cop. £35 above B.S.
†Phos. Tin (5%) £30 above English Ingots.

PIG IRON.

Scotland— Hematite M/Nos.	£3	11	0
Foundry No. 1	3	12	6
„ No. 3	3	10	0
N.E. Coast— Hematite No. 1	3	8	0
Foundry No. 1	3	10	0
„ No. 3	3	7	6
„ No. 4	3	6	6
Silicon Iron	3	10	0
Forge	3	6	6
Midlands— N. Staffs Forge No. 4	3	7	0
„ Foundry No. 3	3	11	0
Northants— Foundry No. 1	3	10	6
Forge No. 4	3	2	6
Foundry No. 3	3	7	6
Derbyshire Forge	3	6	0
„ Foundry No. 1	3	14	0
„ Foundry No. 3	3	11	0
West Coast Hematite	3	7	0
East „ „	3	8	0

SWEDISH CHARCOAL IRON AND STEEL.

Kr. per English ton @ 18–16 to £1 approximately.

Pig Iron Kr. 97
Billets Kr. 230-290 £12 13 4–£16 0 0
Wire Rods Kr. 265-320 £14 12 6–£17 12 6
Rolled Bars (dead soft) Kr. 185-210 £10 4 0–£11 11 0
Rolled Charcoal Iron Bars Kr. 290 16 0 0
All per English ton, f.o.b. Gothenburg.

SCRAP METAL.

Copper Clean	£28	0	0
„ Braziery	26	0	0
„ Wire		—	
Brass	20	0	0
Gun Metal	26	0	0
Zinc	10	0	0
Aluminium Cuttings	68	0	0
Lead	11	0	0
Heavy Steel— S. Wales	2	16	6
Scotland	2	14	6
Cleveland	2	14	0
Cast Iron— Midlands	2	7	6
S. Wales	2	7	0
Cleveland	2	14	0
Steel Turnings— Cleveland	1	17	6
Midlands	1	13	6
Cast Iron Borings— Cleveland	1	10	0
Scotland	2	0	0

SPELTER.

G.O.B. Official		—	
Hard	£12	0	0
English	15	0	0
India	14	5	0
Re-melted	15	0	0

STEEL.

Ship, Bridge, and Tank Plates Scotland	£8	15	0
North-East Coast	8	15	0
Midlands	8	17	6
Boiler Plates (Land), Scotland	9	0	0
„ „ (Marine) „		—	
„ „ (Land), N.E. Coast	10	0	0
„ „ (Marine) „	10	10	0
Angles, Scotland	8	7	6
„ North-East Coast	8	7	6
„ Midlands	8	7	6
Joists	8	15	0
Heavy Rails	8	10	0
Fishplates	12	0	0
Light Rails £8 10 0 to	8	15	0
Sheffield— Siemens Acid Billets	9	2	6
Hard Basic £8 2 6 and	8	12	6
Medium Basic £6 12 6 and	7	2	6
Soft Basic	6	0	0
Hoops £9 10 0 to	9	15	0
Manchester Hoops £9 0 0 to	10	0	0
Scotland, Sheets 24 B.G.	10	5	0

HIGH SPEED TOOL STEEL.

Finished Bars 14% Tungsten	lb.	2/-
Finished Bars 18% Tungsten	„	2/9
Extras		
Round and Squares, ½ in. to ¼ in.	„	3d.
Under ¼ in. to $\frac{1}{16}$ in.	„	1/-
Round and Squares 3 in.	„	4d.
Flats under 1 in. × ⅛ in.	„	3d.
„ „ ⅛ in. × ¼ in.	„	1/-

TIN.

Standard Cash	£234	5	0
English	235	0	0
Australian		—	
Eastern	235	0	0
Tin Plates I.C. 20 × 14 box	0	16	6

ZINC.

English Sheets	£23	10	0
Rods	29	0	0
Battery Plates		—	
Boiler Plates		—	

* McKechnie Brothers, Ltd., quoted Mar. 14. † C. Clifford & Son, Ltd., quoted Mar. 14. ‡ Murex Limited, quoted Mar. 14.

Subject to Market fluctuations. Buyers are advised to send inquiries for current prices.

Prices quoted Mar. 14, ex warehouse.